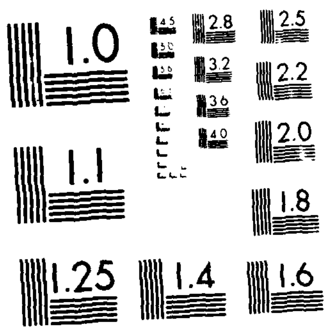

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The inability of the armed services to accurately forecast their spares requirements has been an ongoing and widespread problem. This Note considers a regression methodology for spares requirements forecasting. It contains a nontechnical description of current forecasting approaches, presents the approach suggested by the authors, and details the methods used to calculate the requirements for the C-5, the F-15, and the F-16 aircraft. The authors conclude that, even after eliminating collections of parts whose costs are difficult to predict, costs for the remainder of the requirements are difficult to predict with the needed accuracy.

A RAND NOTE

N-2615/2-P&L

ORACLE and Requirements Forecasting, Vol. II: Predicting the Peacetime Spares Requirements

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F. W. Finnegan

May 1988

Prepared for
The Office of the Assistant Secretary of Defense for
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PREFACE

ORACLE (*O*versight of *R*esources *A*nd *C*apability for *L*ogistics *E*ffectiveness) is a methodology developed to abstract aggregate relations from the U.S. Air Force's Recoverable Item Requirements Computation System, which is also referred to as D041. However, D041 is now being modified to incorporate the Aircraft Availability Model's (AAM) approach to common items, indenture relationships, and an aircraft availability objective based upon no cannibalization. The current method for computing the ORACLE database does not allow for any of these features Therefore, Volume I of this report investigates how these new features could be included. Volume II addresses ORACLE-like procedures that could be used to improve requirements forecasts.

This Note was prepared for the Office of the Assistant Secretary of Defense for Production and Logistics under the auspices of RAND's National Defense Research Institute, the OSD-sponsored Federally Funded Research and Development Center at RAND. The work was performed under the project titled "Effective Modeling."

SUMMARY

Volume II of this report, *ORACLE and Requirements Forecasting, Vol. II: Predicting the Peacetime Spares Requirements,* considers a regression methodology for spares requirements forecasting. The inability of the armed services to accurately forecast their spares requirements has been an important and widespread problem.

Using regression analysis for spares requirements is not a new idea. Both the Air Force Logistics Command's ALERT study and the Air Force Cost and Management Analysis Office's POSSEM study use regression analysis. Many studies by the other services have attempted to use regression analysis, either alone or in conjunction with other analytical tools.

This study attempts to incorporate several ideas that seemed both sensible and important in facilitating more accurate forecasts of the future peacetime spares requirements for aircraft. These ideas have not been adequately tried.

Collections of aircraft parts that can be identified by their federal stock class will, regardless of the analytic method used, be difficult to predict and will include parts where repeated modification programs may make accurate forecasting impossible. Such collections should be removed from the data that are treated by objective analytical methods and singled out for subjective attention. Removing these classes of ill-behaved parts should improve the accuracy of the analytic prediction problem for the remainder of the parts. Singling out these collections of "hard to handle" parts should also increase the chances that these collections would receive the necessary subjective attention.

Approaches that apply regression techniques to the cost of spares requirements as computed in prior years are hypothesized to be saddled with an avoidable problem: The requirement computation techniques have been changing, hence previous year requirements costs have an externally induced variation that makes forecasting much more difficult. Using past data on aircraft parts (old tapes from the D041 system) and writing

a model to mimic the Air Forces D041 requirements system permitted avoidance of these externally induced cost perturbations. This model has generated, for this study, the spares requirements by year and by federal stock class, using a constant and unchanging methodology.

Although these propositions seem reasonable, the data analyzed here suggest that these considerations do little to make the spare parts forecasting problem more tractable.

The requirements data and the flying hour program were used for the C-5, the F-15, and the F-16 aircraft. There has been no difficulty in isolating collections of parts that are poorly behaved from a cost prediction point of view, but eliminating these collections and using a constant and unchanging requirements methodology on the remainder has had little or no effect in making spares costs easier to predict.

In short, the problem is extremely difficult. That was clear before, but it is even clearer now.

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I. INTRODUCTION

ORACLE (*O*versight of *R*esources *A*nd *C*apability for *L*ogistics *E*ffectiveness) is a methodology developed to relate dollars expended on recoverable components to the goals set in the Planning, Programming, and Budgeting (PPB) process.[1] This methodology is designed to systematically abstract aggregate relations between dollars and goals from the U.S. Air Force's Recoverable Item Requirements Computation System (D041). However, the current version of ORACLE is designed to work with a simplified version of D041, rather than the actual version. (The problems associated with extending the current version have been addressed in ORACLE and in Vol. I of this work.)

Among the important needs for an ORACLE-like model is the annual preparation of the Program Objective Memorandum (POM), which describes the activities and capabilities to be achieved over a five year period in the future and time phased dollar amounts required to achieve them. The Air Force Logistics Command (AFLC) uses the D041 computation as the basis for its inputs to the POM. However, that computation makes forecasts for only about three years beyond its most recent data update, and the *initial* inputs to the POM must extend out seven years. Consequently, there is a need to make forecasts well beyond D041's time horizon. In the past, a cost-per-flying-hour rate has been used to forecast these POM requirements, but they have been substantially underestimated.

This Note will investigate the following two questions:

1. How can the ORACLE estimation methodology be modified so it can work with the actual version of D041?
2. And how can a methodology similar to ORACLE improve the accuracy of the POM requirements forecasts?

Volume I of this report considered the first question, and Vol. II considers the second.

The problem of estimating the POM requirements has received much attention. In 1983, near the end of a period of rapidly escalating inflation, the cost-per-flying-hour approach had resulted in several years of D041 predictions that were only about 50 percent of the subsequent requirement. Many of the shortcomings of that approach were addressed in the *Corona Require* committee report.[3] Many of these shortcomings, although serious and generally accepted, are endemic to the approach. In answer to the need for long range forecasts of requirements, several other tools have been suggested.[4,5] This Note details several methods of increasing the accuracy of these research efforts.

Analyzing all weapon systems was beyond the scope of this project. We have concentrated on three fairly new and modern weapon systems that seem characteristic of the aircraft making up the bulk of the Air Force for the coming years: the C-5, the F-15, and the F-16.

In this analysis we were motivated by, and examined, three hypotheses:

1. A constant requirements methodology and the converting of prices to constant year dollars with reasonable inflation indices would make the BP15 requirement more stable and more readily predictable.
2. Breaking the total requirement for a weapon system into several federal stock class (FSC) groupings and analyzing the regression of each group on the several explanatory variables would permit identification of certain groups that do not regress well and hence deserve expert attention and judgment to predict their requirement.
3. Removing these "hard to predict" groupings for individual attention would make the remainder of the expenditure substantially more stable and easier to predict.

In the first point we were wrong. These simple measures, which to the best of our knowledge had not been adequately tried before, did little to make sense of the erratic behavior of the BP15 requirement.

In short, the problem is very hard. We knew that before we began, of course, but we know it better now.

In the second point we believe the data support us. Even after correcting for outliers, some FSC groupings track very poorly with the explanatory variables we have used; and in view of their wild swings, they will probably track poorly with other feasible explanatory variables. These groups need expert attention to predict their out year requirements.

Nothing in the data we have examined here gave us any faith in the third point. Assuming the converse, that removing the bad FSC groups makes forecasting the requirement even more difficult for the remaining FSC groups, is illogical. The small sample size makes the message inconclusive, but these data suggest that removing the bad FSC groups will not greatly alter the difficulty of the prediction problem for the remaining groups.

This Note contains a nontechnical description of current forecasting approaches and our suggested approach (Secs. II and III). Section IV details the methods used to calculate the requirements for the above weapon systems. Sections V through VIII explain the analysis and give the results for the C-5, the F-15, and the F-16. Our conclusions are given in Sec. IX.

II. CURRENT FORECASTING APPROACHES

The Recoverable Consumption Item Requirements System (D041) makes quarterly estimates of the requirements to buy and repair components.[6] The Air Force Logistics Command (AFLC) uses the D041 computation as the basis for its inputs to the POM. However, the D041 computation makes forecasts for only about three years beyond the asset cutoff date. If AFLC's input to the POM is to cover the five POM years, then it is necessary for projections to be made about seven years beyond asset cutoff.

COST PER FLYING HOUR

One current solution to this problem is to calculate the average cost per flying hour in the following way. The total buy requirements from the Budget Estimate Submission (BES) are partitioned among weapon systems, and the buy requirement associated with a particular weapon system is divided by that system's programmed flying hours. The term "cost per flying hour" does not describe the total gross requirements per flying hour; it refers only to the buy requirement divided by the flying hours. To project buy requirements beyond D041's horizon, these average cost factors are multiplied by the flying programs for future years.[3]

This approach can potentially lead to major errors in estimates of future buy requirements for several reasons. First, each cost factor represents average rather than marginal cost. Because there is an inventory of components that has already been bought and paid for, a portion of the flying program can be supported without any new purchases. New components must be bought only when more flying is done than is supportable by assets on hand. Although the average cost approach attributes the cost of additional components to all flying hours, the marginal cost approach attributes this cost to only the excess flying hours. It follows that the average cost per flying hour is less than the marginal cost per flying hour. When the average cost factors are used with a flying program that increases over time, the forecast buy requirements will be underestimated. More accurate results would be obtained if marginal cost factors were used instead.

Another source of error is that the same cost factors are used for each year of the POM. However, these factors may change because of aging. In particular, aircraft operating costs are said to be less during mature (6-14) years, but higher in early (1-5) and in later (15-25) years. Furthermore, modifications of the weapon system may cause the cost factors to change over time. Consequently, the use of constant factors does not allow an adequate treatment of either aging or system modifications.

POSSEM FORECASTING MODEL

Because the preceding forecasting approach seriously underestimated the true spares requirements in recent years, other approaches have been investigated. The Peacetime Operating Stocks Spares Estimating Model (POSSEM) was developed by the USAF/ACM (United States Air Force/Cost and Management Analysis), and it will be described next.[5]

For each weapon system (MD), POSSEM considers two dependent variables: annual buy requirements for peculiar items and annual buy requirements for all items, both peculiar and common. Also for each weapon system, POSSEM considers several exogenous predictor variables: reciprocal of the aircraft age, aircraft value (flyaway costs plus modifications), and aircraft utilization rate.

The POSSEM methodology consists of the following steps: first, obtain historical buy requirements for peacetime operating stock, by weapon system, for both peculiar and common items; second, obtain historical estimates for the exogenous predictor variables; third, convert all dollar estimates into units corresponding to the most recent year; fourth, for each weapon system, use linear regression analysis to relate the dependent variables to the predictor variables; fifth, develop future estimates of the predictor variables for each weapon system; and sixth, by substituting the future estimates of the predictor variables into the regression formulas, forecast the buy requirements for peacetime operating stock in future years.

The USAF/ACM exercised this POSSEM methodology in the following way. They obtained historical data for each fiscal year from 1975 through 1982, converted all dollar estimates into 1982 dollars, and developed the linear regression formulas. Using future estimates of the predictor variables from 1983 through 1985, they forecast the buy requirements for those years. And, finally, after comparing the forecasts from the foregoing POSSEM methodology with the BES estimates made by D041, they found that the POSSEM estimates were generally higher than the BES estimates for each weapon system, but with a few exceptions.

However, there are several limitations with the POSSEM methodology. First, the approach used for handling common items is quite crude. The procedure was to obtain estimates of the historical buy requirements for common items, as a group, during each past fiscal year. These common requirements were then allocated to the individual weapon systems based upon allocation percentages that were constant over time. However, this constancy is suspect, because the set of common items varies over time and because the percentage of an item's assets that is associated with a given weapon system varies among the common items and also over time.

Another problem with POSSEM is its use of "requirements" as computed by a methodology that has changed over time. In particular, USAF/ACM used buy requirements computed by D041 from 1975 through 1982. However, before June 1976, D041 computed fixed safety levels for all items; but after this date, variable safety levels were used for some items. As another example, in 1980 the procurement leadtime was changed from one to two years. The point is that some of the annual variation in buy requirements is due to variation in the computation program, rather than in the predictor variables. Consequently, when forecasting future buy requirements with POSSEM, some error might be introduced by using regression formulas based upon data generated by obsolete versions of D041. It would be better to recompute the buy requirements for each of the past years while using only the latest version of D041, and then base the regression formulas on these recomputed data.

ALERT FORECASTING MODEL

The Air Logistics Early Requirements Technique (ALERT) is another macro procedure for forecasting peacetime operating stock, and it was developed by AFLC/MM (Air Force Logistics Command/Materiel Management).[4] This technique has two types of formulas. The first type forecasts requirements during each budget year within D041's horizon and attempts to improve the accuracy of D041's predictions. The second type forecasts requirements for years outside of D041's horizon. Because the second type is essentially the same as POSSEM, this subsection will discuss only the first type of formula.

Three approaches are available for forecasting the buy requirements within D041's horizon: directly using the forecasts from D041; using POSSEM for those years; or using ALERT, which can be viewed as a combination of the first two approaches. ALERT is similar to POSSEM, because a regression formula is used to predict the buy requirements for each weapon system (MD) as a function of certain predictor variables. But unlike POSSEM, ALERT uses D041's own forecast as one of its predictor variables. Specifically, ALERT uses two predictor variables: the D041 computed forecast plus one enhancer variable, which is either the aircraft value, reciprocal of the aircraft age, or the year.

Another difference between POSSEM and ALERT is in the treatment of common items. POSSEM attempts to allocate the common items to the different weapon systems, whereas ALERT treats the common items as a separate category. For each budget year within D041's horizon, ALERT develops a regression formula for the common items as a single group; and for each budget year and weapon system, ALERT develops a regression formula for the associated peculiar items.

The AFLC/MM exercised this ALERT methodology in the following way. Historical data were obtained for each fiscal year between 1977 and 1983. Regression formulas were then developed for each weapon system, using both the ALERT and POSSEM methodologies. For each budget year within D041's horizon, it was found that the ALERT formulas provided a better fit to the historical data than did the POSSEM formulas.

The ALERT methodology also has some limitations. First, no effort is made to correct for inflation by converting dollar estimates into constant dollars. As a result, error could be introduced if the rate of inflation in the future is different from that in the past. Second, ALERT does not provide any significant improvement over POSSEM for the budget years beyond D041's horizon, because these two techniques are essentially the same for those years.

III. A SUGGESTED FORECASTING APPROACH

WHAT IS THE "TRUE" REQUIREMENT?

The problem of calculating the "true" requirement for the current or coming years is a complicated compromise: The dollar value of the BP15 spares requirement must be matched with the need for other requirements--inclusive and exclusive of logistics--and the dollars available.

Although there may be disagreements about the best spares computation methodology, if future requirements are to be estimated partly on the basis of trends in past requirements, past requirements should be calculated by the methodology that will be in effect when the dollars are spent. To the best of our knowledge both the ALERT and POSSEM studies use past requirements as calculated on the basis of past requirements methodologies.[1]

Unfortunately the Air Force's requirements computation has changed several times over the last ten years: The number of parts purchased to cover random variations in the number in resupply is called the safety level. In March 1977 a decision was implemented to change from a calculation that used a fixed safety level (equal to the square root of 3 times the expected number in resupply) to a variable safety level (equal to the square root of a variable times the expected number in resupply). This change was made to bring the D041 procedure more nearly in line with "marginal analysis" computations that attempt to optimize aircraft availability at a constant or minimum cost. Other policy changes affected safety levels in 1981.[3] Although not the subject of this Note, the future requirements for War Readiness Material (WRM) suffer from these problems in even bigger ways. WRM levels are set on the basis of policy decisions about the war we expect we may have to fight, how long it will take to get repair into the theater, how long it

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[1]The AFLC "Alert" Study minimized this confusion by using post 1977 data only.

will take to repair parts in wartime, and several other variables that are set by policy, as opposed to the peacetime requirement, which is largely driven by empirical data.

POLICY DECISIONS AFFECT THE "TRUE" REQUIREMENT

In recognition of the increasing lead times required to procure complex avionics and other aircraft parts, a policy decision was made in 1980 to change the procurement lead time from one year to two years in the D041 computation. This affects the BP15 computation in any given year by advancing the purchases of parts needed in subsequent years. The effect on the cumulative requirement in subsequent years is small, but the change resulted in a one time increment in the requirements computations done in 1980 with regard to those done in other years.

The use of unrealistic inflation indices has contributed to past errors in D041 computations of out year requirements.[3] In 1982 AFLC studied the actual inflation of military aircraft components as measured by the change in the historical buy prices in J041. This study showed that the Office of Management and Budget (OMB) inflation rates that had been used earlier substantially understated requirements. To minimize the effects of this error we have used the AFLC inflation indices.

FORECASTING APPROACHES: MICRO, MACRO, ART, OR SCIENCE?

Current forecasting techniques can be characterized as focusing on a micro approach--that is, rolling out the buy requirement item by item (as is done by D041)--or extremely macro: computing a marginal cost per flying hour by weapon system, or computing the cost per weapon system and trending that cost on certain independent variables (see the ALERT and POSSEM discussions above).

The disadvantages of the item by item approach have been documented in several studies, including the Corona Require[3] study group report, and the ALERT[4] and POSSEM[5] studies. A big disadvantage is that much of the cost of replacement parts in future years is generated by the need for part types that are currently not in the inventory. These requirements are completely missed by rolling out the costs for the items that are in the current inventory. Nor are there sufficient compensating errors: The item manager of items that are in the current inventory that are to be phased out should have manually adjusted the future demand rates in the D041 file to compensate for the intended phase out. Failure to phase out obsolete parts does not occur often enough to compensate for the failure to include parts not currently in the inventory.

Macro approaches, which attempt to look at total costs by weapon system and roll them out into the future years, seem to suffer from lack of attention to future modifications and changes in operating procedures. Approaches such as ALERT and POSSEM capture the future in gross measures such as flying hours or number of squadrons, but price escalation resulting from future modifications of avionics, for example, are not captured.

Forecasting future spares requirements seem to be part science and part art. Most components are amenable to any or all of the above forecasting procedures, but many are amenable to none. Those that do not seem to trend with other known variables must be given individual attention and expert judgment.

In addition to identifying parts, or classes of parts, that require individual attention and expert judgment, a forecasting procedure should readily lend itself to "what-if" questions: While AFLC has the responsibility for formulating future requirements, the POM process requires that the Air Staff have the ability to juggle budgets and make estimates of the budget effect of flying a given Mission Design Series (MDS) more and another MDS less in the future years.

The original ORACLE methodology provided derivatives of the spares requirements cost with respect to several variables of interest. These derivatives, which allowed the accurate estimation of budgets under excursions from the planned schedules, were numerically estimated within the framework of the D041 mathematical calculations.

Because extending this ORACLE methodology to the aircraft availability objective was not feasible at RAND,[2] we have chosen to pursue empirically estimating derivatives using regression techniques.

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[2]Since our initial interest in extending the ORACLE technology to

The procedure we have used is in the middle ground between the micro and the macro approaches discussed above.

THE FEDERAL STOCK CLASS CODES

The first four digits of the National or Federal Stock Number of a part are the Federal Stock Class (FSC), which identifies the type of component and generally determines the depot and shop where the item is replaced (see App. C).

In the approach we have used, the D041 parts with application to a given weapon system have been grouped by their FSC codes. Because many of these codes have few or no parts that apply to a given weapon system, the FSC codes were collected into a dozen or so groupings per weapon system.

The intent of the grouping is to identify, with regression techniques, those classes following trends that can be predicted with observed variables (age of the fleet, flying hours, etc.) and to identify other classes that historically do not lend themselves to prediction on the basis of these variables, so that the latter classes can be singled out for expert attention and judgment regarding their future budget requirements.

In other words, the intent is to use regression analysis to divide the reparable parts of a weapon system into two groups, those whose requirements can be predicted with science, and those whose requirements must be predicted with art. The same analysis then gives the equations to forecast the requirements for the well-behaved parts.

Removing the poorly behaved classes from the regression analysis should improve the overall accuracy of the forecast. The out year costs in these troublesome categories must be estimated using expert judgment, including knowledge of modification programs, intended avionics upgrades, and re-engining. The need for expert judgment must be emphasized and given attention, and an important aspect of this approach is the ability to isolate the troublesome FSC groups.

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requirements calculations using an aircraft availability objective, Logistics Management Institute has built the calculation of derivatives into their Aircraft Availability Model (AAM).

FORECAST CUMULATIVE BUY REQUIREMENTS OR MARGINAL BUY REQUIREMENTS?

The current D041 POM procedure is a mixture of philosophies. On the one hand, it attempts to forecast the marginal buy requirement for each of the out years. On the other hand, where the size of the BP15 budgets are known and contain shortfalls, the procedure takes the shortfall in a given year, the "unfunded carryover," and adds it into the following year's requirements. Ignoring the unfunded shortfall would clearly be inappropriate, but assuming all of the unfunded shortfall will be required in subsequent years is also inappropriate; it ignores the reality of the variation in the D041 parameters that ultimately results in many--perhaps most--parts being stocked in greater than required quantities.[3] In other words, among the parts that D041 assumes should be purchased but are not because of the shortfall, some will turn out to be unnecessary in the next year as a result of changes in the demand rate, the condemnation rate, the resupply time, or policy. (Resupply time is used here to describe the weighted sum of the expected base repair time and the depot resupply time, weighted by the probability of base repair and its complement.)

This predicament is characteristic of the forecasting problem: Both the cumulative requirement and the marginal requirement depend, in different ways, on past purchase histories, and those histories depend on past D041 data, not just current and future data. In short, trying to relate future requirements to current and future data has some obvious shortcomings. Recognition of those shortcomings undoubtedly influenced the selection of the current D041 calculation, which unfortunately has its own share of problems.

It became clear that for our purposes there were problems with forecasting either the cumulative buy requirements or the marginal buy: Using known variables for the current and the out years to estimate the cost, even in an aggregate way, of spare parts in the coming years is

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[3] Carrying over the entire shortfall may result in an unknown degree of bias that inflates the BP15 budget, but throughout the D041 system there are many other more important biases that tend to understate the requirement.[3]

difficult--the cumulative requirement depends in large part on past history and past needs. In addition, small errors in the estimation of the cumulative requirement result in large errors in the estimation of the marginal requirement, and it is the marginal requirement that must ultimately be budgeted for in any given year. Using current and out year variables to explain the yearly marginal increases in requirements also has problems, as the marginal requirement depends somewhat on the current level of the cumulative requirement, which depends on history. In short, the marginal requirement depends on many more factors than can be captured with a few explanatory variables.

Further, at the micro level, the design of the resupply system makes forecasting unavoidably difficult. On the average, roughly 60 percent of all failures of reparable items are satisfied by base level repair and another 30 percent by depot level repair. The remaining 10 percent are covered, as a last resort, by purchases. Thus, swings in the demand for parts that result from changes in the flying hour program or aging of the fleet are typically satisfied without purchases. However, when the swing in expected failures becomes great enough to generate a buy requirement, then the absolute amount of the buy may swing wildly with the small marginal changes in the flying program and in expected failures.

Despite these drawbacks, the BP15 budget must be estimated as well as possible, it is a significant part of the Air Force and Navy budget, and its effect on future readiness is important.

IV. CUMULATIVE BUY REQUIREMENTS

An important part of our proposed forecasting methodology is computing cumulative buy requirements for each weapon system, year, and aggregation group. This section will give a nontechnical discussion of our procedure for computing these requirements, with the technical description relegated to the appendices.

DATA SOURCE

The main source of our data is the D041 Data Bank Records for the years 1975 through 1984. These data files were received on magnetic tape from AFLC and Synergy, Inc. For each year, it was possible to have up to 50 records of information for each item. However, as discussed in App. A, some records were not available because of damaged or unreadable tapes. It was necessary to do some preliminary data processing to eliminate certain inconsistencies.

The items used to illustrate the forecasting methodology have the following characteristics: They are recoverable components stocked sometime between 1975 and 1984; apply to either the C-5, F-15, or F-16 aircraft; are not engine parts; and have an OIM (organizational intermediate maintenance) program based upon operating hours. Altogether, we considered 4905 items applying to the C-5, 4318 items applying to the F-15, and 1858 items applying to the F-16.

REQUIREMENTS MODELS

The D041 computes replenishment spares requirements for recoverable items. This model has evolved over time with three main stages:

1. *Fixed safety levels*. The safety level is additional stock protecting in case the demand exceeds the mean projection. A fixed safety level is computed independently of an item's price. Before June 1976, all items had fixed safety levels.

2. *Variable safety levels.* A variable safety level is developed through a cost effectiveness technique called "marginal analysis." The level varies according to greatest need, subject to an item's price and a budget constraint. From June 1976 to the present time, some items have had variable safety levels and others have had fixed safety levels.
3. *Aircraft availability.* The D041 model is currently being modified so that aircraft availability rates will be related to expenditures for procurement and depot repair of recoverable spares. With this modification, D041 will be similar to LMI's Aircraft Availability Model (AAM) discussed in Volume I.

The foregoing modifications in D041 produce variability in the requirements forecasts over time, which in turn will distort any effort to determine historical trends through regression analysis. Consequently, a key feature of our proposed forecasting methodology is to recompute the historical requirements model, thereby eliminating any distortion due to model changes.

Our initial plan was to demonstrate our methodology by using LMI's computer code for the AAM, since that was judged as being representative of the future D041. However, we rejected that approach because we discovered that LMI's code was not portable, in the sense that it could not be run on RAND's IBM computer.

We therefore developed our own simplified D041 computation model that could illustrate all features of our proposed forecasting methodology, including using a uniform model to recompute the cumulative buy requirements for past years, in this case for each year from 1975 through 1984; allocating the assets of common items to each associated weapon system, which requires a complex procedure because a given item could have multiple applications with different indenture levels; and computing the cumulative buy requirements for arbitrary groupings of items within each weapon system. This simplified model is described in App. B, uses fixed safety levels, is similar to the version of D041 in use before June 1976, and is based upon an earlier simplified version of D041 that was developed by Bigelow[2].

The main difference between the various versions of D041 is in the way the safety stock is computed; other aspects of these models are generally the same. Because the safety stock is only a small portion of the total gross requirements, we believe the performance of our proposed forecasting methodology does not depend upon the particular requirements model used for demonstration.

For a given item, weapon system, and year, the cumulative buy requirement is a function of the following quantities:

- Total assets (serviceable, net unserviceable, due in, and on order) at asset cutoff in the first year that the item is stocked;
- Actual condemnations (base and depot) from asset cutoff in the first year through asset cutoff in the given year;
- Projected condemnations due to operating requirements (organizational intermediate maintenance and depot level maintenance) from asset cutoff in the given year through the end of the buy period (end of fiscal year plus procurement leadtime);
- Level requirements (base and depot pipelines, safety stock, etc.) at end of the buy period following asset cutoff in the given year;
- Additive requirements (war reserve material, etc.) at the end of the buy period following asset cutoff in the given year;
- Cumulative buy requirements for the preceding year.

Using data from the D041 Data Bank Records discussed in App. A and the formulas for the simplified D041 computation model given in App. B, each of the above quantities can be evaluated for each item, which permits computation of the cumulative buy requirements for each item. The next step is to sum the item requirements to obtain the cumulative buy requirements for each aggregation group. The final step in the proposed methodology is to perform the regression analyses.

V. REGRESSION ANALYSIS, BACKGROUND

THE CHOICE OF WEAPON SYSTEMS

For this analysis we chose three modern weapon systems that are, and will continue to be, characteristic of much of the active Air Force: the F-15 and the F-16 fighters and the C-5 strategic transport. These aircraft each account for roughly 6-7 percent of the BP1500 budget. In addition they are, and will continue to be, an important part of the Air Force for years to come.

As we began analyzing the database it became apparent that only the C-5 had been in the Air Force long enough for a valid ten year history of BP15 requirements to be constructed. Although the F-15 and the F-16 had been in the inventory in earlier years, the early BP15 expenditures could not be expected to be characteristic of the patterns of expenditures for their more mature years. For these reasons we limited our data to the six years from 1977 to 1984 for the F-16, the seven years from 1976 to 1984 for the F-15, and the full ten years from 1975 to 1984 for the C-5.[1] Given that the analysis includes the F-16 with only six years of data we restricted the number of coefficients we would estimate to two.[2]

LINEAR REGRESSIONS

Linear regressions are widely used and reported in all types of literature in the military and in the physical and social sciences, and presumably well understood by readers in these fields. Nonetheless, we believe that they are the most widely misused (perhaps almost universally misused) of statistical tools. It may be helpful to make

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[1]One year's data allow the computation of that year's cumulative requirement. Ten (or seven or six) years of data allows the computation of nine (or six or five) years of annual marginal requirements.

[2]We tried using additional variables in the case of the C-5. It did not improve the results and had some drawbacks that are mentioned below.

clear why we have used them and the ways they may be useful and the ways they may be misleading. Our use of the terms and concepts of regression analysis may differ from those commonly found in reports and studies. (For more about linear regressions see Ref. 7.)

Regressions are widely used because they provide a framework for relating a variable of interest (the dependent variable) to other variables (the independent or explanatory variables) that may be observed or predicted. Fundamental to a linear regression is the "General Linear Hypothesis" stating that the mean of the variable of interest, the dependent variable, lies in a certain linear plane (possibly a "hyperplane" of dimension greater than 2) that is defined by linear combinations of the explanatory variables.

In addition to the linear hypothesis, it is usually further assumed that the signed distances between the hyperplane and the observations (the residuals) are normally distributed with a precisely described covariance matrix. In this case (and in most others) we believe there is good reason to question this distributional assumption. Although certain F statistics have been given in the tables of regression results for those wishing to make this leap of faith, we have concentrated on looking at the distances from the observations to the best fitting hyperplane. If these distances were small relative to the size of the observations, we would believe that the hyperplane fits well in the regions where we have data and further investigation could be helpful in quantifying the predictive ability of our estimates of the hyperplane or regression equation. Unfortunately the fit is not adequate, in our minds, to justify further concerns.

In other words, we are doing a loose approximation of what others might call a regression analysis. We are not assuming, nor are we trying to convince the reader, that the residuals have a certain joint normal distribution, or that an acceptable fit in the regions where we have data implies this fit will continue into the regions where it is necessary to make projections. Similarly, the reader may find our treatment of what are called "outliers," values of the dependent variable that exhibit erratic behavior with respect to the independent variables, hard to defend rigorously.

The point of proceeding with this relaxation of the fundamental precepts of regression analysis is that if the fit of the data points to the hyperplane of interest is not very good under these conditions, it will be worse in a more demanding analysis. In our opinion the user of this or any other regression analysis ought to treat these implicit assumptions with a healthy degree of skepticism. In this case the fit of the data to the hyperplane is not very good. There is therefore little to recommend our addressing the missing, and harder, questions that ought to be part of a regression analysis.

Regardless of the analyst's faith (or lack of it) in the distribution of the residuals, the first steps of a regression procedure are the same. The procedure uses n observations of the dependent variable and the corresponding values of the independent variables and mathematically solves for the hyperplane that is closest to the observed dependent variable (expressed as a vector, or a point y in n dimensions).

This hyperplane is important. Finding it is equivalent to solving for the coefficients of the explanatory variables that best predict the dependent variable.

The squared distance from the n dimensional dependent variable to the hyperplane is also important. The squared distance from y to its closest point in the hyperplane (measured perpendicularly to the hyperplane) is called the "residual sum of squares" and measures the variation of y that is not explained by the explanatory variables. The squared distance from this closest point to the mean of y (or to the origin in the case of a regression through the origin), measured along a line within the hyperplane, is called the "sum of squares attributable to the model." The total squared distance from y to its mean (or the origin) is the sum of these two squares (the line from y to its mean is the hypotenuse of a right triangle, one of whose legs is in the hyperplane and the other perpendicular to it). The ratio of the sum of squares attributable to the model to the total squared distance (this ratio is called R^2) gives a measure of the goodness of fit of the hyperplane relative to the magnitude of the variable y.

In general, a perfect, true linear relationship between the independent variables and the expected value of the dependent variable is too much to hope for. The optimistic analyst will hope that a linear fit is "fairly close" in the region where he is working--that is, in the region where the data lie. To assume a good linear fit well outside the region with data without other supporting rationale is only a wild guess disguised as statistical analysis.

This bodes ill for predicting BP15 budgets. For growing weapon systems we will always be faced with making predictions out into an area where flying hours, age, and value of the fleet exceed the corresponding parameters in historical data. The analyst's preference would be to predict into the future in small steps, recalculating the projections every year. Unfortunately the federal government's need, hence the Air Force's need, is to predict expenditures well out into the future, in some cases seven years.

In short, using linear analysis for these projections (as is done in POSSEM and ALERT) is not necessarily a good idea, it just is the best idea currently available with our knowledge, or lack of it. Our goal is not to be able to make these projections accurately, it is merely to consider methods of making them better.

THE CHOICE OF EXPLANATORY, OR INDEPENDENT, VARIABLES

The variable of interest in these regressions is the marginal annual cost of the BP15 requirement for a particular MD. This is the variable we will observe over the history of our data files and attempt to discern patterns that allow predicting costs, by FSC classes, out into the future. With the limited history that is appropriate for observation, the problem of chosing the explanatory (or independent) variables is more difficult. For the sake of uniformity and consistency we chose to use the same explanatory variables for all three aircraft. We are constrained in this choice by the lack of more than six years of data for the F-16.

The analysis reported here takes repeated and excessive liberties in subjective areas, such as rejecting outliers and replacing their values. In some cases a better course of action would be just to delete the questionable points. Because we are concerned with regressions of individual FSC classes as well as their sum, deleting points in the individual FSC classes would quickly reduce the number of suitable points in the sum to such a small number that we could not analyze them with these methods. Even with these questionable manipulations, the results of our analysis of these data is not very encouraging.

The output of a linear regression will be a hyperplane defined by the product of certain coefficients (estimates of the coefficients are given by the analysis) and the observed explanatory variables. One must decide whether this hyperplane should be constrained to pass through the origin. In other words, if all of the explanatory variables happen to be 0, will the BP15 expenditure for a weapon system be 0? There are repair requirements on aircraft whether they fly or not, and there is no apparent physical reason to constrain the hyperplane to go through the origin.

However, an analytic or statistical reason for constraining the hyperplane to go through the origin is to avoid the possibility that the line becomes negative in feasible regions of the explanatory variables. For example, flying sufficiently few hours would drive the spares cost to zero, or even more absurd, it would become negative. Additionally, the unconstrained hyperplane leaves an additional parameter to be estimated, which is a disadvantage if the intercept is expected to be near the origin and the sample size is small. We tried both methods and found the constrained regressions gave better results.

Among the competing predictors for the other two explanatory variables were the average age of the fleet, flying hours, and the value of the fleet. Until recently, the Air Force has not used "value of the fleet" as a predictor by the Air Force, but the Navy has long used it to predict Naval Air requirements. (Value of the fleet has also been used by AF/AC in the POSSEM model.)

It is commonly believed that age enters into the cost of supporting a weapon system in a very nonlinear way. In the early years the cost of supporting a weapon system is expected to be high: Initial provisions must be purchased. As experience is gained, some parts are apt to require redesign and replacement. In addition, all of the unexpected contingencies associated with a new weapon system must be met. After the first few years, the annual parts costs are expected to drop sharply and then rise again slowly as components begin to wear out and subsystems are modified and replaced with more modern systems. (The costs of modifications are not directly funded from BP15 funds; however, a modification is apt to make a portion of the spare parts inventory obsolete and require the purchase of another set of spares to support the modified subsystem. Official policy to the contrary, such purchases are often funded from BP15.)

The plot of these purchases usually forms a curve called the bathtub curve, but it cannot be seen in the weapon systems that we chose. The characteristic rising tail seems to be missing, possibly as a result of the young age of these systems. But many FSC classes do exhibit a characteristic high level of funding in the early years, which then drops sharply. To facilitate predicting this age-induced cost, we have included the quantity 1/(1+avage), where "avage" is the average age of the fleet, as one of the explanatory variables. The reciprocal of average age, 1/(avage), which is used in the AF/AC POSSEM model, was considered and rejected because it drops unrealistically fast when age is close to 0.[3] In the sequel we will refer to the quantity 1/(1+avage) simply as "age" or the "age factor."

Several studies have found little dependence of spares cost on flying hours or sorties. We have nonetheless chosen to include flying hours as an explanatory variable for several reasons.

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[3]Using the reciprocal of average age plus a constant opens questions regarding the appropriate constant. We have used 1 because the resulting curve "looks about right," and the data are too noisy to permit finer subtleties in the determination of the explanatory variables.

First, as mentioned above, the data do not suggest estimating more than two or three coefficients. One of these will be the age factor mentioned above. Because the age factor is decreasing, the other variable should be an operationally related curve that is increasing in the later years. Value of the fleet is a candidate, but with the noisy data we found little difference in the results when comparing the degree of fit using value of the fleet and flying hours.[4]

Additionally, many spare parts fail as a result of repeated physical stress or wear that is a direct result of flying, taking off, or landing.[5] Although sorties may provide a better explanation of failures than flying hours for some parts, flying hours are more often tracked in Air Force data systems and forecasts of future activity. Further, for a given weapon system, curves describing sorties per year tend to look like the curves that describe flying hours by year; and for an analysis with noisy data, done on an annual basis, that implies they are apt to be equally good explanatory variables. In short, some parts fail either as a direct result of flying hours or as a result of variables that track well with flying hours, and flying hours may be effectively used as a surrogate explanatory variable for all of these parts.

To explain the spares purchases made in, say, 1983, what flying hour figures should be used? Options are the forecast flying hours in 1983, 1984, and 1985 or the forecast flying hours for 1986, or some linear combination. Because spares requirements for a given part must consider the procurement lead time for that part, and procurement lead times may vary from one to three years, some linear combination would be most

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[4]Using both variables simultaneously in the analysis of the C-5 resulted in little improvement in R^2, and the near collinearity of the flying hour and value curves made the determination of the unknown coefficients extremely sensitive to slight changes in the data. For these reasons we discarded "value" as an explanatory variable.

[5]Harder to swallow, perhaps, is the seeming lack of a relationship between the failures of many components and such operational measures as flying hours or sorties. It may be that many of the failure modes of expensive complex avionics, for instance, are simply not driven by use.

appropriate. The precise linear combination may be unimportant: Flying hour curves for the aircraft considered are all increasing in the out years, and within reason the curves for different linear combinations have almost identical shapes. We tried several linear combinations and found that the sum of forecast flying hours for one and two years into the future (in this case the sum of flying hours for 1984 and 1985) provided a simple calculation that worked as well as any.

As mentioned above, we have not noticed bathtub curves dominating the data in the case of the C005, F015, or F016. However, linear combinations of the independent variables we have used--the reciprocal of (1+avage) and the flying hour program--will yield bathtub curves if they are present in the data, hence we have not excluded this popular form of the cost curve.

THE CHOICES OF FSC CLASSES

It has been said that predicting the BP15 budget is part art and part science. Our intent is to demonstrate a way of using a regression approach to identify the "art" part and use this same technique to estimate the cost of the "science" part. By using regressions individually on groups of FSC classes we will attempt to determine what predictions can be made with science, and this same analysis will pinpoint those groups of FSC codes that must be brought to the attention of the expert "artists." The groups should not be too big or too small, and should consist of similar items.

By identifying FSC classes that do not appear to be related to the explanatory variables, it is expected that the identification of these irregular classes and their subsequent deletion from the sum to be estimated with regression techniques will improve the fit and the confidence of the forecast. Unfortunately, that is not always the case. An analogy can be drawn with independent normal random variables: Suppose we have a collection of random variables and their means, and we measure goodness of fit by the difference between the sum of the random variables and the sum of their means. We would expect that if we delete those random variables (and their means) where the distance from the mean to the random variable is large (the "outliers"), then we will improve the goodness of fit. But it is easy to see that may not be the case: The outliers may compensate for the errors in the other random variables. This seemingly "unlikely" event occurred in the case of the C-5.

It was necessary to begin the data analysis on a large mainframe capable of handling the large databases on the D041 tapes. After taking an initial and rather arbitrary cut at defining FSC classes, we reduced the data to yield files of cumulative annual requirements for the three weapon systems for the given FSC classes (see Sec. IV). These files were moved into a Compaq Plus personal computer where the subsequent regression analysis was done with a copyrighted package called Stata, which is very demanding about the data format of input files.[6] Two Fortran programs were written to first take the differences between successive year cumulative requirements to generate the marginal buy requirements and then to put this data in a format compatible with Stata.

The initial runs with Stata were made to judge the suitability of the FSC groupings used. (For a listing of the FSC codes, see App. C.) On the basis of these runs, we redefined the FSC classes and reran the requirements computation program. We repeated the above procedure several times. The outcome was the FSC classes shown in Table 1.

As mentioned above, there are ambiguities about the choice of the flying hour variable. We first graphed the flying hour program by year for each MDS, as well as several linear combinations of flying hours for 0, 1, 2, and 3 years into the future. Where there were differences in the shape of the curves we regressed a dependent variable, the total requirement, on age and the different flying hour curves to look for a flying hour choice that predicted as well as, or better than, the others. The result of this comparison was the choice of "fh12," an independent or explanatory variable that uses in, say, 1983 the sum of the flying hour programs for 1984 and 1985.

Recalling that flying hour curves and value curves are similar (very similar in the case of the F-15 and the F-16, less so in the case

[6]A subsequent release of Stata is much more flexible in this regard.

Table 1

FSC CLASSES

FSC Class	FSC	Name
1	1005	Guns, through 30 mm
1	1095	Miscellaneous Weapons
2	1270	Aircraft Gunnery Fire Control Components
2	1270	Aircraft Bombing Fire Control Components
3	1560	Aircraft Structural Components
4	1620	Aircraft Landing Gear Components
4	1630	Aircraft Wheel and Brake Systems
5	1650	Aircraft Hydraulic, Vacuum and De-Icing System
5	1660	Aircraft Air Conditioning, Heating and Pressurizing
6	1680	Miscellaneous Aircraft Accessories and Components
4	2620	Tires and Tubes, Pneumatic, Aircraft
7	2835	Gas Turbines and Jet Engines, Except Aircraft
7	2925	Engine Electrical System Components, Aircraft
7	4810	Valves, Powered
8	4920	Aircraft Maintenance & Repair Shop Specialized Equipment
9	5821	Radio and Television Communication Equipment/Airborne
9	5826	Radio Navigation Equipment, Airborne
11	5841	Radar Equipment, Airborne
11	5865	Electronic Countermeasure Equipment
9	5895	Miscellaneous Communications Equipment, Airborne
7	6110	Electrical Control Equipment
7	6115	Generators and Generator Sets, Electrical
10	6605	Navigational Instruments
10	6610	Flight Instruments
13	6615	Automatic Pilot Mechanisms & Airborne Gyro Compass
10	6620	Engine Instruments
10	6710	Cameras, Action Picture
12	7021	Automatic Data Processing Central Unit
12	7025	Automatic Data Processing Input/Output & Storage Device
14		All Others

of the C-5) we then regressed the total requirement on age and value and again on age and fh12. We found that the differences in the abilities of these variables to predict was inconsequential. Bearing in mind that there is a need to relate the spares requirement to operational elements, especially in the sizing of the WRM budget, we decided to use age and fh12 as the explanatory variables.

VI. REGRESSION ANALYSIS, THE C-5

The C-5 input data are given in Table 2 and summarized in Table 3. As noted, the overall fit of the total cost (fscsum) to the best regression lines gives an R^2 squared of .79. The analysis summarized in Table 3 is presented in App. D, Tables D.1-D.13.

In 1982 the costs associated with fsc8 and fsc9 jumped substantially, as did the costs associated with fsc10 in 1980. In those three instances the difference between the largest and the smallest residual were more than twice the difference between the next largest and the smallest residual. In rechecking the requirements calculation we found that those costs were associated with large, one-time additive requirements. On the assumption that those costs should have been forecast by expert judgment, we replaced those three fsc costs by the average costs for that fsc class for the other eight years.

With the changes mentioned above in fsc classes 8, 9, and 10, the new regressions in these classes are improved as shown in App. D, Tables D.14-D.17. There fscsum was recalculated using the new values for fsc8, 9, and 10. A summary is given in Table 4.

Although these changes resulted in an improved R^2 of .79 to .88, Table 4 shows that several fsc classes relate poorly to the explanatory variables. The effect of selectively deleting these fsc classes from fscsum is represented in Appendix D Tables D.18-D.21. We hoped that omitting these classes would improve the overall fit, but the perverse situation mentioned above occurs here: Deleting fsc5 drops the R^2 from .88 to .87. Deleting fsc12 and fsc3 drops the R^2 to .86. Deleting fsc11 increases the R^2 to .89, insignificantly better than it was before we started this process.

On the positive side, the estimated coefficients that would be used to predict fscsum seem to be fairly robust. In a comparable analysis, where we attempted to take advantage of the larger sample size for the C-5 and include value in our list of explanatory variables, the collinearity of value and flying hours, in the presence of noisy data, resulted in slightly improved R^2, but the estimated coefficients changed drastically with the addition or deletion of small fsc classes.

We have been told that some analysts may be inclined to look favorably on a regression analysis with an R^2 of .89. The dangers of concentrating on R^2, especially in an analysis that has been constrained to pass through the origin (as was pointed out by the reviewer) is exemplified in Appendix Tables D.20 and D.21. Here it is seen that although the R^2 is moderately high, and even after taking some excessive liberties in treating outliers and rejecting troublesome fsc classes, two of the residuals (1980 and 1982) are more than half the size of the average fscsum, hardly reassuring for a method that was being considered for making projections into areas not covered by the data.

Table 2

C-5 INPUT DATA

Observation						
1	year	1976.	value	7673.	age	.143
	fsc3	25677.	fsc4	8638.	fsc5	9692.
	fsc6	4550.	fsc7	4318.	fsc8	19918.
	fsc9	11490.	fsc10	34874.	fsc11	15018.
	fsc12	41937.	fsc13	4979.	fsc14	3388.
	fscsum	184479.	fh12	97669.		
2	year	1977.	value	7696.	age	.125
	fsc3	2614.	fsc4	5713.	fsc5	1848.
	fsc6	5644.	fsc7	2429.	fsc8	26185.
	fsc9	9069.	fsc10	29424.	fsc11	18205.
	fsc12	10431.	fsc13	8120.	fsc14	6801.
	fscsum	126483.	fh12	96935.		
3	year	1978.	value	7711.	age	.111
	fsc3	2167.	fsc4	9447.	fsc5	17242.
	fsc6	3225.	fsc7	1617.	fsc8	20616.
	fsc9	4982.	fsc10	2350.	fsc11	1102.
	fsc12	611.	fsc13	3064.	fsc14	1741.
	fscsum	68164.	fh12	99796.		
4	year	1979.	value	7739.	age	.100
	fsc3	3942.	fsc4	7839.	fsc5	4215.
	fsc6	649.	fsc7	822.	fsc8	10831.
	fsc9	3992.	fsc10	945.	fsc11	1051.
	fsc12	7.	fsc13	3322.	fsc14	860.
	fscsum	38475.	fh12	103393.		
5	year	1980.	value	7835.	age	.091
	fsc3	4950.	fsc4	24082.	fsc5	20622.
	fsc6	3177.	fsc7	2293.	fsc8	2753.
	fsc9	5441.	fsc10	64948.	fsc11	23724.
	fsc12	1227.	fsc13	26484.	fsc14	5160.
	fscsum	184861.	fh12	105296.		
6	year	1981.	value	8267.	age	.083
	fsc3	11204.	fsc4	10358.	fsc5	1288.
	fsc6	1099.	fsc7	791.	fsc8	129.
	fsc9	4929.	fsc10	3091.	fsc11	3140.
	fsc12	2006.	fsc13	9803.	fsc14	1496.
	fscsum	49334.	fh12	107393.		

Table 2 (continued)

Observation						
7	year	1982.	value	8502.	age	.077
	fsc3	14512.	fsc4	15897.	fsc5	12839.
	fsc6	4249.	fsc7	4319.	fsc8	58591.
	fsc9	14908.	fsc10	9501.	fsc11	12422.
	fsc12	6.	fsc13	12375.	fsc14	6828.
	fscsum	166447.	fh12	113827.		
8	year	1983.	value	8803.	age	.071
	fsc3	24755.	fsc4	2715.	fsc5	157.
	fsc6	2649.	fsc7	814.	fsc8	2.
	fsc9	406.	fsc10	5368.	fsc11	338.
	fsc12	14.	fsc13	12514.	fsc14	514.
	fscsum	50246.	fh12	117311.		
9	year	1984.	value	9305.	age	.067
	fsc3	342.	fsc4	8071.	fsc5	1086.
	fsc6	1346.	fsc7	173.	fsc8	64.
	fsc9	1432.	fsc10	1550.	fsc11	423.
	fsc12	10912.	fsc13	776.	fsc14	7714.
	fscsum	33889.	fh12	117653.		

Table 3

SUMMARY OF THE INITIAL ANALYSIS, C-5

Variable	Mean	Fraction of Total Cost	R^2
fsc3	10018.1111	.10	.56
fsc4	10306.6667	.10	.75
fsc5	7665.44444	.08	.55
fsc6	2954.22222	.03	.85
fsc7	1952.88889	.02	.74
fsc8	10062.2222	.15	.45
fsc9	5217.66667	.06	.74
fsc10	10887.8889	.17	.49
fsc11	8380.33333	.08	.59
fsc12	7461.22222	.07	.55
fsc13	9048.55556	.09	.61
fsc14	3833.55556	.03	.68

Table 4

SUMMARY OF THE SECOND ANALYSIS, C-5

Variable	Mean	Fraction of Total Cost	R^2	
fsc3	10018.1111	.10	.56	
fsc4	10306.6667	.10	.75	
fsc5	7665.44444	.08	.55	
fsc6	2954.22222	.03	.85	
fsc7	1952.88889	.02	.74	
fsc8	10062.2222	.15	.88	(up from .45)
fsc9	5217.66667	.06	.94	(up from .74)
fsc10	10887.8889	.17	.77	(up from .49)
fsc11	8380.33333	.08	.59	
fsc12	7461.22222	.07	.55	
fsc13	9048.55556	.09	.61	
fsc14	3833.55556	.03	.68	
fscsum	100264.222	1.0	.88	(up from .79)

VII. REGRESSION ANALYSIS, THE F-15

The F-15 input data are given in Table 5. Appendix D Tables D.22-D.37 present the results of the initial regression, which are summarized in Table 6.

In this first cut at the data there were residuals in the four classes fsc9, fsc11, fsc13, and fsc14 that are outliers by our criteria: The difference between the maximum and the minimum value of the residuals is more than twice the difference between the next largest value and the minimum value. Accordingly, we have replaced these four values with the average of the other six years in their fsc classes and recomputed the regressions in Appendix D Tables D.36-D.40. These altered values are used in all analysis subsequent to these tables, which are summarized in Table 7.

In Table 7 there are four fsc classes with an R^2 less than .65. The results of successively deleting these classes from fscsum is shown in Appendix D Tables D.41 and D.42. Deleting fsc classes 1 and 12 (which together account for only 1 percent of the costs) and fsc4 (which is responsible for 12 percent of the cost) the R^2 changes slightly from .93 to .94. Deleting fsc4 (7 percent of the cost) brings the R^2 back to .92.

Again, although an R^2 over .90 may seem acceptable, Table D.42 makes it clear that several of the residuals are between a third and a half of the average fsc value; this does not lend much confidence to the fundamental problem of making predictions about future spares budgets.

Table 5

F-15 INITIAL DATA

Observation						
1	year	1978.	age	.454	fsc1	76.
	fsc2	3647.	fsc3	23355.	fsc4	28378.
	fsc5	28042.	fsc6	1781.	fsc7	22275.
	fsc8	0.	fsc9	13444.	fsc10	56947.
	fsc11	320006.	fsc12	34.	fsc13	7922.
	fsc14	9483.	fscsum	515390.	fh12	197447.
	value	4495.				
2	year	1979.	age	.370	fsc1	120.
	fsc2	7938.	fsc3	67330.	fsc4	31252.
	fsc5	10806.	fsc6	1780.	fsc7	6070.
	fsc8	0.	fsc9	9525.	fsc10	29398.
	fsc11	107977.	fsc12	236.	fsc13	9461.
	fsc14	2621.	fscsum	284514.	fh12	234557.
	value	6177.				
3	year	1980.	age	.322	fsc1	526.
	fsc2	6222.	fsc3	37673.	fsc4	110035.
	fsc5	23199.	fsc6	1945.	fsc7	7875.
	fsc8	0.	fsc9	9259.	fsc10	7313.
	fsc11	669457.	fsc12	4209.	fsc13	6246.
	fsc14	148668.	fscsum	1032627.	fh12	276325.
	value	8276.				
4	year	1981.	age	.278	fsc1	114.
	fsc2	15536.	fsc3	21552.	fsc4	14744.
	fsc5	11174.	fsc6	2819.	fsc7	12444.
	fsc8	0.	fsc9	15422.	fsc10	41545.
	fsc11	287291.	fsc12	8027.	fsc13	5282.
	fsc14	10605.	fscsum	446555.	fh12	313550.
	value	9807.				
5	year	1982.	age	.208	fsc1	0.
	fsc2	5499.	fsc3	156749.	fsc4	13009.
	fsc5	41711.	fsc6	1950.	fsc7	34340.
	fsc8	0.	fsc9	7220.	fsc10	29801.
	fsc11	281644.	fsc12	702.	fsc13	26024.
	fsc14	20203.	fscsum	618852.	fh12	339274.
	value	12187.				

Table 5 (continued)

Observation						
6	year	1983.	age	.144	fscl	0.
	fsc2	6244.	fsc3	37274.	fsc4	848.
	fsc5	19097.	fsc6	3948.	fsc7	20350.
	fsc8	0.	fsc9	6454.	fsc10	13112.
	fsc11	108304.	fsc12	103.	fsc13	6149.
	fsc14	10416.	fscsum	232299.	fh12	360902.
	value	15725.				
7	year	1984.	age	.125	fscl	360.
	fsc2	394.	fsc3	3470.	fsc4	3477.
	fsc5	8041.	fsc6	1331.	fsc7	17061.
	fsc8	0.	fsc9	7981.	fsc10	8578.
	fsc11	188024.	fsc12	5290.	fsc13	1540.
	fsc14	50070.	fscsum	295617.	fh12	378176.
	value	16478.				

Table 6

SUMMARY OF THE INITIAL ANALYSIS, F-15

Variable	Mean	Fraction of Total Cost	R^2
fscl	170.857143	.00	.47
fsc2	6497.14286	.01	.71
fsc3	49629.	.10	.53
fsc4	28820.4286	.06	.53
fsc5	20295.7143	.04	.78
fsc6	2222.	.01	.89
fsc7	17202.1429	.04	.81
fsc8	0.	.00	***
fsc9	9900.71429	.02	.95
fsc10	26670.5714	.05	.84
fsc11	280386.143	.57	.75
fsc12	2657.28571	.01	.50
fsc13	8946.28571	.02	.60
fsc14	36009.4286	.07	.36
fscsum	489407.714	1.00	.81

Table 7

SUMMARY OF THE SECOND ANALYSIS, F-15

Variable	Mean	Fraction of Total Cost	R^2	
fsc1	170.857143	.00	.47	
fsc2	6497.14286	.02	.71	
fsc3	49629.	.12	.53	
fsc4	28820.4286	.07	.53	
fsc5	20295.7143	.05	.78	
fsc6	2222.	.01	.89	
fsc7	17202.1429	.04	.81	
fsc8	0.	.00	***	
fsc9	8980.42857	.02	.99	(up from .95)
fsc10	26670.5714	.07	.84	
fsc11	215541.	.54	.90	(up from .75)
fsc12	2657.28571	.01	.50	
fsc13	6100.	.02	.94	(up from .60)
fsc14	17233.	.04	.75	(up from .36)
fscsum	402019.571	1.00	.93	(up from .81)

VIII. REGRESSION ANALYSIS, THE F-16

The F-16 input data are given in Table 8 and the results of the initial regression are given in Appendix D Tables D.43-D.55 and summarized in Table 9. In the initial regressions the 1981 fsc1 and the 1980 fsc5 expenditures stand out as clear outliers (although several others are close). Together fsc1 and fsc5 account for only about 1 percent of the cost of parts for the F-16, and the correction of these outliers would have no noticeable effect on the R^2 for fscsum. The 1984 fsc14 value is an outlier and was replaced by the average of fsc14 in the other five years. Fsc7 had a clearly decreasing trend, except that the first year, 1978, was very low. For fsc7 we have replaced the 1979 and 1980 values with their average. Since fsc7 and fsc14 contribute only 2 percent and 4 percent of the costs of the spares for the F-16, we expect these changes to have little effect.

The second set of regressions, with these outliers removed, is summarized in Table 10. The regressions are in Appendix D Tables D.56-D.58.

In Table 10 the four fsc classes with R^2 values less than .75 (fsc1, fsc5, fsc6, and fsc14) total only 7 percent of fscsum. These classes would be recommended for expert judgment. Deleting those fsc classes results in virtually no change as shown in Appendix D Tables D.59-D.60. The presence of very large outliers in those tables bodes ill for this method as a means of predicting spare parts budgets.

Table 8

F-16 INITIAL DATA

Observation						
1	year	1979.	age	.588	fsc1	7.
	fsc2	125581.	fsc3	31543.	fsc4	7272.
	fsc5	2045.	fsc6	8288.	fsc7	2332.
	fsc9	1065.	fsc10	99886.	fsc11	18142.
	fsc13	23921.	fsc14	178.	fscsum	320260.
	fh12	69183.	value	471.		
2	year	1980.	age	.588	fsc1	0.
	fsc2	264433.	fsc3	414284.	fsc4	14318.
	fsc5	21453.	fsc6	49666.	fsc7	19748.
	fsc9	3881.	fsc10	136910.	fsc11	39628.
	fsc13	8789.	fsc14	9518.	fscsum	982628.
	fh12	142135.	value	1468.		
3	year	1981.	age	.415	fsc1	565.
	fsc2	126421.	fsc3	168288.	fsc4	2178.
	fsc5	3127.	fsc6	10900.	fsc7	13683.
	fsc9	5007.	fsc10	43235.	fsc11	7052.
	fsc13	20809.	fsc14	3207.	fscsum	404472.
	fh12	233787.	value	4219.		
4	year	1982.	age	.350	fsc1	7198.
	fsc2	28770.	fsc3	123853.	fsc4	15105.
	fsc5	1452.	fsc6	9688.	fsc7	15004.
	fsc9	5423.	fsc10	11650.	fsc11	9910.
	fsc13	9495.	fsc14	1529.	fscsum	239077.
	fh12	331830.	value	5475.		
5	year	1983.	age	.254	fsc1	34.
	fsc2	43037.	fsc3	164266.	fsc4	7871.
	fsc5	4967.	fsc6	6755.	fsc7	6649.
	fsc9	3065.	fsc10	26659.	fsc11	52646.
	fsc13	729.	fsc14	8034.	fscsum	324712.
	fh12	416044.	value	7838.		
6	year	1984.	age	.225	fsc1	1619.
	fsc2	110735.	fsc3	78009.	fsc4	6535.
	fsc5	5580.	fsc6	15931.	fsc7	4150.
	fsc9	5375.	fsc10	11330.	fsc11	86829.
	fsc13	3827.	fsc14	95073.	fscsum	424993.
	fh12	474853.	value	9474.		

Table 9

SUMMARY OF THE INITIAL REGRESSION, F-16

Variable	Mean	Fraction of Total Cost	R^2
fsc1	1570.5	.00	.34
fsc2	116496.167	.26	.84
fsc3	163373.833	.36	.70
fsc4	8879.83333	.02	.82
fsc5	6437.33333	.01	.56
fsc6	16871.3333	.04	.67
fsc7	10261.	.02	.76
fsc9	3969.33333	.01	.92
fsc10	54945.	.12	.92
fsc11	35701.1667	.08	.77
fsc13	11261.6667	.03	.82
fsc14	19589.8333	.04	.53
fscsum	449357.	1.00	.84

Table 10

SUMMARY OF THE SECOND ANALYSIS, F-16

Variable	Mean	Fraction of Total cost	R^2	
fsc1	1570.5	.00	.34	
fsc2	6496.1	.01	.84	
fsc3	163373.8	.38	.70	
fsc4	8879.8	.02	.82	
fsc5	6437.3	.01	.56	
fsc6	16871.3	.04	.67	
fsc7	10261.	.02	.91	(up from .76)
fsc9	3969.3	.01	.92	
fsc10	54945.	.13	.92	
fsc11	35701.1	.08	.77	
fsc13	11261.6	.03	.82	
fsc14	4493.2	.01	.67	(up from .53)
fscsum	434260.3	1.00	.84	(unchanged)

IX. CONCLUSIONS

With the exceptions mentioned below, the data for the C-5 and the F-15 yielded the kind of analysis we expected. The initially computed R^2 was modest, about .8, and improved with the rejection of outliers to about .9. The F-16, probably as a result of its youth as a weapon system, was less amenable to analysis. Although they did not meet our rather arbitrary definition of outliers, for many FSC classes the 1979 requirement was low, and the 1980 requirement was high. 1979 was the first year of our data, and the growing pains and problems associated with a small, new fleet of complicated airplanes may have severely affected the data in those early years.

It was our intent to demonstrate three things in this regression analysis:

1. With a constant requirements methodology and prices converted to constant year dollars with reasonable inflation indices, the BP15 requirement would be more stable and more readily predictable.
2. Breaking the requirement into federal stock class groupings and analyzing the regression of each group on the explanatory variables would permit identification of certain groups that do not regress well and deserve expert attention and judgment to predict the requirement.
3. Removing these "hard to predict" groupings for individual attention would make the remainder of the expenditure substantially more stable and easier to predict.

In the first point we were wrong. These simple measures, which to the best of our knowledge had not been adequately tried before, did little to make sense of the erratic behavior of the BP15 requirement.

In the second point we believe the data support us. Even after we correct for outliers, some FSC groupings track very poorly with the explanatory variables we have used; and in view of their wild swings, they will probably track poorly with other feasible explanatory variables. The idea that parts of the BP15 budget need expert opinion and judgment is not new. Unfortunately, although that idea has common acceptance, the needed expert attention often gets overlooked. These areas must be brought to the attention of AFLC management, and responsible individuals must be designated to learn the intricacies of these areas and help with the forecasting of BP15 expenditures in the out years. We believe that regression analysis by FSC groups and weapon system can identify the "hard to predict" FSC groups.

Nothing in the data we have examined here give us any faith in the third point. Assuming the converse, that removing the bad FSC groups makes forecasting the requirement for the remainder harder, is illogical. The small sample size makes the message inconclusive, but these data suggest that removing the bad FSC groups will not greatly alter the difficulty of the prediction problem for the remaining groups.

Appendix A

DEPOT DATA BANK

This appendix identifies the data used in generating the file structure required by the simplified D041 computation model. The key source for the data was the D041 Data Bank Records, which is a computerized version of the Recoverable Consumption Item Requirements System,[6] for the years 1975 through 1984.

The data files were received on magnetic tape from two sources:

1975-1980 AFLC/XRSA (Barbara J. Wieland)

1981-1984 Synergy, Inc. (Hugh Hinman)

For each year it was possible to have over 50 types of records. Only those listed in Table A.1 were used in this study. As indicated in Table A.2 the files had a cutoff date of 30 June or 30 September, with some record types not available for all years, because of damaged and unreadable tapes at the source or the re-identification of record types. For instance, record type 29 in years 1975-1977 was changed to record type 42 for the years 1978-1984.

To generate the database, it was also necessary to obtain data regarding flying hours and federal supply classes. The flying hour data, for various years, were obtained from Ref. 8 and various other Air Force sources. The federal supply class data were obtained from Ref. 9.

Table A.3 displays the stock number counts by D041 record type. A significant change occurred in the counts for record types 19-28 between 1978 and 1979. In the years 1975-1978 record types 19-28 contained forecast data. In 1979 these data were no longer collected but the record types were used for collecting requirements data.

Table A.4 displays the counts after preliminary data processing to combine some of the record types into a single record by stock number. The reduction in the stock number count for record type 50 is due to the elimination of all records for stock numbers not having an application to at least one MDS. The count for record type 13 reflects the summation, by stock number, of record types 13-14 for years 1975-1978

Table A.1

RECORD TYPE DESCRIPTIONS

Data Type	Record Type
Descriptive Data	01
Usage and Past Program Data	
Base Condemnations	05
Total Depot Condemnations	08
Total Overhaul Condemnations	10
Due-In and On-Order Assets	12
Requirements:	
Prepositioned WRM Requirements	13
Bench Mock-Up	14
Test Stand	15
Turnaround Support Kit	16
High Priority Mission Support Kit	17
Retrofit/Modification	18
War Consumable	19
Government Furnished Equipment and Materiel	20
Military Assistance Sales--Pilot Training	21
Training--Guidance and Control System	22
Support Equipment	23
Special Projects	24
Mobile Training Units	25
Installation	26
Mission Direct	27
Wholesale Interservice Supply Support Agreement Additive	28
Foreign Military Sales Additive	29
Special Program Requirement Planned	30
Bailment	31
On-Hand Assets	42
Application Data	50

Table A.2

RECORD TYPES IN-HOUSE

Type	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
01	J	J	J	J	S	J	S	S	S	S
05	J	J	J	J	S	J	S	S	S	S
08	J	J	J	J	S	J	S	S	S	S
10	J	J	J	J	S	J	S	S	S	S
12		J		J	J	J	S	S	S	S
13		J	J	J	J	S	S	S	S	S
14		J	J	J	J	S	S	S	S	S
15		J	J	J	J	S	S	S	S	S
16		J	J	J	J	S	S	S	S	S
17		J	J	J	J	S	S	S	S	S
18					J	S	S	S	S	S
19	J	J	J	S	J	S	S	S	S	S
20	J	J	J	S	J	S	S	S	S	S
21	J	J	J	S	J	S	S	S	S	S
22	J	J	J	S	J		S	S	S	S
23	J	J	J	S	J	S	S	S	S	S
24	J	J	J	S	J	S	S	S	S	S
25	J	J	J	S	J	S	S	S	S	S
26	J	J	J	S	J	S	S	S	S	S
27					J	S	S	S	S	S
28	J	J	J	S	J	S	S	S	S	S
29	J	J	J		J	S	S	S	S	S
30					J	S	S	S	S	S
31					J	S	S	S	S	S
42				J	J	J	S	S	S	S
50	J	J	J	J	J	J	S	S	S	S

J = 30 JUNE
S = 30 SEPTEMBER

and is merely record type 13 for years 1979-1984. The count for record type 14 reflects the summation, by stock number, of record types 15-16 for years 1975-1978, and of record types 14-28 and 30-31 for years 1979-1984. The count for record type 29 is record type 17 for years 1975-1978 and is record type 29 for years 1979-1984.

Table A.5 shows the final record layout of the file structure used by the simplified D041 model. Beneath the heading "Variable Source," the numeric values refer to D041 record types. The entry for the row labeled "YEAR" can have the value 75-84. The entry for the row labeled "VECTOR" is a nine position variable used to indicate the absence of data, such as zeros or blanks in all variables; the definition for this variable is given at the bottom of Table A.5.

Table A.6 depicts the allowable items to which a Master Stock Number can have application. For this study, application types ACFT MDS (lines 1-5) and NATL. STK. NR. (line 13) were used to select Master Stock Numbers for processing.

Because of inconsistencies in how MDS and stock numbers were entered in some of the D041 type 50 records, we made some changes to have them conform to the table. Examples of the records changed are: an MDS application shown as F15A, F-15A, or F015A, meant to identify an application to the F015A, was changed to F015A; and when the same stock number was sometimes shown with the Material Management Code (MMC) and sometimes blank, the MMC was removed from all records (in both the Master Stock Number and Application Fields). In those cases where any change caused duplicate application records in the file, a test was made to delete the records that had been changed, while retaining the record that had not been changed.

The final Record Type 50 Application File eventually contained all Master Stock Numbers that had application to an MDS for which annual flying hour data were available. Table A.7 lists every MDS that was used. For processing by the simplified D041 model, all data were aggregated to the stock number/model design level. A numeric MD code, defined in Table A.8, was added to the file for selection control.

The asset data in the D041 were contained in Record Type 29 for the years 1975 through 1977, and Record Type 42 for the years 1978 through

Table A.3

RAW DATA: NSN COUNTS BY RECORD TYPE

Record Type	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
01	124810	132418	137099	144378	144402	146543	149657	155111	161075	170107
05	5698	4919	4519	4033	4033	3181	3340	2426	1955	1666
08	11305	11727	11528	12059	12059	11623	11668	10478	10795	10608
10	8717	9846	9164	8958	8958	8425	8790	7924	8116	7737
12	0	13852	0	15359	18262	18506	18562	21297	21283	28261
13	0	9625	8932	10652	13057	13049	13777	11717	11651	11942
14	0	1032	401	1108	51	128	106	88	109	96
15	0	2821	2967	1997	35	16	23	32	54	67
16	0	10	18	8	4	84	102	27	161	39
17	0	7736	7435	8120	1096	1066	583	611	633	1139
18	0	0	0	0	111	138	113	146	147	189
19	74197	77745	78336	71083	53	25	30	40	46	46
20	2192	2672	2622	2788	39	82	70	75	99	282
21	5809	5533	5841	5407	52	89	66	60	61	59
22	1204	1188	1212	1167	1	0	1	2	2662	2855
23	8503	9092	9655	9579	153	100	125	183	192	57
24	3084	2936	3049	2948	288	415	326	323	483	494
25	7905	8766	8232	96	76	100	69	49	35	30
26	520	926	935	840	133	202	145	174	228	319
27	0	0	0	0	426	1222	1135	1228	1528	1655
28	2611	2259	2468	1411	272	590	666	755	914	1146
29	96807	100062	103612	0	8232	9466	10900	8710	9008	8564
30	0	0	0	0	68	244	281	237	220	223
31	0	0	0	0	570	748	904	1109	1208	1279
42	0	0	0	107465	106761	105016	118461	155111	161075	129937
50	113202	117974	121850	124987	124005	132157	136125	130890	121249	145728

Table A.4

PROCESSED DATA: NSC COUNTS BY RECORD TYPE

Record Type	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
01	124810	132418	137099	144378	144402	146543	149657	155111	161075	170107
05	5696	4919	4515	4030	4025	3181	3340	2426	1955	1666
08	11303	11726	11522	12049	12055	11620	11668	10478	10795	10608
10	8716	9846	9159	8942	8948	8423	8790	7924	8116	7737
12	13811	13852	13764	15266	18254	18502	18562	21297	21283	28261
13	10105	10119	9079	11014	13049	13043	13777	11717	11651	11942
14	2825	2827	2967	1998	3344	4668	4182	4414	7403	8092
29	7721	7735	7422	8105	8228	9454	10900	8710	9008	8564
42	96799	100062	103600	107384	106740	105009	118461	155111	161074	129937
50	39005	37875	42522	36245	35912	41871	44009	44217	42392	45752

Table A.5

MODEL INPUT RECORD LAYOUT

Data Field Name	Field Size	Record Position	Variable Source
MASTER_STOCK_NUMBER	15	001-015	01
YEAR	2	016-017	Constant
VECTOR	9	018-026	Compute[a]
ITEM_NAME	10	027-036	01
ERRC_CODE	1	037-037	01
ITEM_CATEGORY	1	038-038	01
PROGRAM_SELECT_CODE	4	039-042	01
NEW_ITEM_CODE	1	043-043	01
CONTING_DEFER_DISPOSE_LEVEL	5	044-048	01
INSURANCE_NSO_BUY_LEVEL	5	049-053	01
UNIT_PRICE	9	054-062	01
UNIT_REPAIR_COST	9	063-071	01
BASE_REPAIR_CYCLE_DAYS	3	072-074	01
BASE_ORDER_AND_SHIP_DAYS	2	075-076	01
TOTAL_DEPOT_REPAIR_CYCLE_DAYS	3	077-079	01
ADMIN_LEADTIME_MONTHS	1	080-080	01
PRODUCTION_LEADTIME_MONTHS	2	081-082	01
NJR_STOCK_LEVEL_DAYS	2	083-084	01
JR_STOCK_LEVEL_DAYS	2	085-086	01
DEPOT_FLOATING_STOCK_LEVEL	3	087-089	01
TOTAL_OIM_DEMAND_RATE	5	090-094	01

Table A.5 (continued)

OIM_BASE_REPAIR_RATE	5	095-099	01
OIM_DEPOT_DEMAND_RATE	5	100-104	01
BASE_CONDEMNATION_PERCENT	3	105-107	01
PDM_NJR_REPAIR_PERCENT	3	108-110	01
PDM_NJR_REPLACE_PERCENT	3	111-113	01
PDM_JR_CONDEMNATION_PERCENT	3	114-116	01
EOH_NJR_REPAIR_PERCENT	3	117-119	01
EOH_NJR_REPLACE_PERCENT	3	120-122	01
EOH_JR_CONDEMNATION_PERCENT	3	123-125	01
MISTR_NJR_REPAIR_PERCENT	3	126-128	01
MISTR_NJR_REPLACE_PERCENT	3	129-131	01
MISTR_JR_CONDEMNATION_PERCENT	3	132-134	01
DEPOT_OH_CONDEMN_PERCENT	3	135-137	01
NUMBER_OF_USERS	3	139-140	01
PRESTOCKED_REQUIREMENT	7	142-147	01
NEGOTIATED_BASE_STOCK LEVEL	7	149-154	01
DUE IN SERVICEABLE	7	155-161	12
DUE IN UNSERVICEABLE	7	162-168	12
DUE IN ON ORDER	7	163-175	12
DUE IN TOC	7	176-182	12
ASSETS SERVICEABLE	7	183-189	42
ASSETS UNSERVICEABLE	7	190-196	42
ASSETS WRM	7	197-203	42
ASSETS TOC	7	204-210	42
PREPOSITIONED WRM REQUIREMENT	7	211-217	13
OTHER ADDITIVE REQUIREMENTS	7	218-224	14-28
FMS ADDITIVE	7	225-231	29
BASE CONDEMNATION (8 QUARTERS)	7	232-287	05
DEPOT CONDEMNATION (8 QUARTERS)	7	288-343	08
OVERHAUL CONDEMNATION (8 QUARTERS)	7	344-399	10
PERCOM	7	400-406	COMPUTE
QPA	10	407-416	COMPUTE
INDENTURE LEVEL	1	417-417	COMPUTE
MD CODE	3	418-420	COMPUTE

[a]POSITION:

18 RECORD TYPE 01 (DESCRIPTIVE DATA)
19 RECORD TYPE 05 BASE CONDEMNATION
20 RECORD TYPE 08 DEPOT CONDEMNATION
21 RECORD TYPE 10 OVERHAUL CONDEMNATION
22 RECORD TYPE 12 DUE IN / ON ORDER
23 RECORD TYPE 13 PREPOSITIONED WRM REQUIREMENT
24 RECORD TYPE 14-32 (exclude 13,29) OTHER ADDITIVES
25 RECORD TYPE 29 FMS ADDITIVE
26 RECORD TYPE 42 ASSETS

Table A.6

APPLICATION DATA FORMAT

	APPLICATION	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	ACFT MDS			B	0	5	2	E								
2	ACFT MDS		K	C	1	3	5	A								
3	ACFT MDS	N	K	C	1	3	5	A								
4	ACFT MDS		C	H	0	0	3	E								
5	ACFT MDS	F	X	F	0	0	5	A							U	K
6	ENG TM			J	0	0	5	7	0	5	5	A				
7	ENG TM	G	R	0	0	8	5	1	8	0						
8	ENG TM	F	X	H	0	0	7	9	0	1	1	A				
9	ENG TM	G	S	0	0	4	8	0	B	1	0	A	6			
10	MISSILE MDS	A	I	M	0	2	6	B								
11	DRONE MDS		Q	F	1	0	2	A								
12	TRAINER	1	A	D	0	0	0	A								
13	NATL. STK. NR.	1	6	5	0	0	0	1	2	3	4	5	6	7	L	H
14	PEC	5	6	0	1											
15	PEC	1	0	0	3	2										
16	SYSTEM NETWORK	8	1	6	L											

Table A.7

MDS: SEQUENCE NUMBER ASSOCIATION IN FINAL MASTER FILE

SEQ	MDS	SEQ	MDS	SEQ	MDS	SEQ	MDS
1	A007D	53	AC130H	105	VC137C	156	F111A
2	A007K	54	DC130H	106	C140A	157	EF111A
3	A010A	55	EC130H	107	C140B	158	F111D
4	A037B	56	HC130H	108	VC140B	159	F111E
5	OA037B	57	NC130H	109	C141A	160	F111F
6	B001A	58	WC130H	110	C141B	161	TH001F
7	RB047H	59	HC130N	111	E003A	162	UH001F
8	B052D	60	HC130P	112	E003B	163	HH001H
9	B052E	61	C131A	113	E004A	164	UH001H
10	B052F	62	C131B	114	E004B	165	UH001N
11	B052G	63	C131D	115	F004C	166	UH001P
12	B052H	64	C131E	116	RF004C	167	CH003B
13	B057C	65	C131H	117	F004D	168	CH003C
14	B057E	66	NC131H	118	F004E	169	CH003E
15	FB111A	67	VC131H	119	FXF004E	170	HH003E
16	C005A	68	C135A	120	F004F	171	HH043F

Table A.7 (continued)

SEQ	MDS	SEQ	MDS	SEQ	MDS	SEQ	MDS
17	C006A	69	EC135A	121	FXF004F	172	HH053B
18	VC006A	70	KC135A	122	F004G	173	CH053C
19	C007A	71	NC135A	123	F005A	174	HH053C
20	C009A	72	RC135A	124	FXF005A	175	HH053H
21	C009C	73	NKC135A	125	F005B	176	HH060A
22	VC009C	74	C135B	126	FXF005B	177	UH060A
23	KC010A	75	EC135B	127	F005E	178	O001E
24	C018A	76	WC135B	128	FXF005E	179	O002A
25	C047A	77	C135C	129	F005F	180	O002B
26	EC047Q	78	EC135C	130	FXF005F	181	TR001A
27	C054D	79	KC135D	131	F015A	182	TR001B
28	C097G	80	RC135D	132	TF015A	183	T029B
29	KC097L	81	C135E	133	F015B	184	VT029B
30	C118A	82	EC135E	134	F015C	185	T029C
31	VC118A	83	KC135E	135	FXF015C	186	VT029C
32	C121C	84	NKC135E	136	F015D	187	T029D
33	C121G	85	EC135G	137	FXF015D	188	VT029D
34	EC121S	86	EC135H	138	F016A	189	T033A
35	EC121T	87	EC135J	139	F016B	190	T037B
36	C123J	88	EC135K	140	F100D	191	FXT037B
37	C123K	89	EC135L	141	F100F	192	T038A
38	UC123K	90	RC135M	142	F101B	193	FXT038A
39	C124C	91	C135N	143	RF101C	194	T038B
40	C130A	92	EC135N	144	F101F	195	AT038B
41	AC130A	93	EC135P	145	F102A	196	T039A
42	DC130A	94	KC135Q	146	F104G	197	CT039A
43	RC130A	95	KC135R	147	TF104G	198	T039B
44	C130B	96	RC135S	148	FTF104G	199	T043A
45	WC130B	97	RC135T	149	FXF104G	200	U001A
46	C130D	98	RC135U	150	F105B	201	U003A
47	C130E	99	RC135V	151	F105D	202	U004B
48	DC130E	100	RC135W	152	F105F	203	U006A
49	EC130E	101	EC135Y	153	F105G	204	HU016B
50	MC130E	102	C137B	154	F106A	205	OV010A
51	WC130E	103	VC137B	155	F106B	206	UV018B
52	C130H	104	C137C				

Table A.8

MD: SEQUENCE NUMBER ASSOCIATION IN MODEL INPUT FILE

SEQ	MD	SEQ	MD	SEQ	MD	SEQ	MD
1	A007	17	C097	32	F015	47	0002
2	A010	18	C118	33	F016	48	R001
3	A037	19	C121	34	F100	49	T029
4	B001	20	C123	35	F101	50	T033
5	B047	21	C124	36	F102	51	T037
6	B052	22	C130	37	F104	52	T038
7	B057	23	C131	38	F105	53	T039
8	B111	24	C135	39	F106	54	T043
9	C005	25	C137	40	F111	55	U001
10	C006	26	C140	41	H001	56	U003
11	C007	27	C141	42	H003	57	U004
12	C009	28	E003	43	H043	58	U006
13	C010	29	E004	44	H053	59	U016
14	C018	30	F004	45	H060	60	V010
15	C047	31	F005	46	0001	61	V018
16	C054						

1984. The individual fields of the D041 records were summed to create the following fields on the model input records:

Assets Serviceable:

Serviceable Base and Depot Assets

Serviceable Contractor Assets

Serviceable Intransit Assets

Assets Unserviceable:

Unserviceable Base Assets

Unserviceable Contractor Scheduled

Unserviceable Contractor Assets

Unserviceable Intransit Assets

Unserviceable Depot Assets

Unserviceable Bailment Assets

Unserviceable WRM Depot Assets

Unserviceable Due-in from Overhaul

DOTM Assets

Assets WRM:

Serviceable WRM Base Assets
Serviceable WRM Depot Assets

Assets TOC:

TOC Assets

The due-in data in the D041 were contained in Record Type 12 for the years 1975 through 1984. The individual fields of the D041 records were summed to create the following fields on the model input records:

Due-in Serviceable:

Due-In GFAE
ISSP Serviceable
Reclamation Serviceable
Termination Serviceable
MAP Excess Serviceable

Due-in Unserviceable:

ISSP Unserviceable
ISSP TOC
Reclamation Unserviceable
Reclamation TOC
Termination Unserviceable
Termination TOC
MAP Excess Unserviceable
MAP Excess TOC

Due-in on Order:

On Order PR Reported
On Order PR Funded
On Order PR Reported Additive
On Order PR Funded Additive
On Order Contract
On Order Contract Additive

Due-in TOC:

Allowed for, but was eventually included in the field: Due-in Unserviceable

The condemnation data in the D041 were contained in the following Record Types for the years 1975 through 1984:

Record Type 08--Depot Condemnations

Record Type 10--Overhaul Condemnations

Condemnation data fields on the D041 file list eight (8) quarters of counts, the oldest quarter being the first listed. The model input file contains the same data, except the newest quarter is the first listed.

Appendix B

SIMPLIFIED D041 COMPUTATION MODEL

INPUT DATA

The main source of data used in this study was the depot data bank for the D041 system. These data were assembled for ten years, 1975 through 1984. For each year, it was possible to have up to 50 records of information for each item. However, as indicated in Table A.2 of App. A, not all records were available to us for every year. For any given record and year, the data came from the D041 computation for either 30 June or 30 September.

Table B.1 lists all of the D041 input factors used in this appendix and indicates the record from which each factor was derived. In what follows, it is assumed that these factors have been scaled in the following way: The factors defined as percentages have been converted into fractions, and the factors defined with respect to units of time have been converted into having units of years.

SET OF ITEMS

Not every item included within the D041 database will be considered in this appendix. The items that will be considered share four characteristics:

1. They are recoverable consumption items stocked sometime between 1975 through 1984;
2. They apply to either the C-5, F-15, or F-16 aircraft;
3. They are not engine parts, because that application field would give an engine rather than an aircraft; and
4. They have an OIM (organizational intermediate maintenance) program based upon operating hours, as determined by the PSC (program select code).

Table B.1

FACTORS FROM DEPOT DATA BANK

Number	Symbol	Description	Record
1	FSC	Federal stock class	1
2	MSC	Master stock number	1
3	PSC	Program select code	1
4	ECCE	ECCC code	1
5	PRICE	Unit price	1
6	BRCD	Base repair cycle	1
7	BOSTD	Base order and ship time	1
8	TDRCD	Total depot repair cycle	1
9	ALT	Administrative leadtime	1
10	PLT	Production leadtime	1
11	SLDNJR	Non-job-routed stock level	1
12	SLDJR	Job-routed stock level	1
13	DFLSL	Depot floating stock level	1
14	TOIMD	Total OIM demand rate	1
15	OIMBRR	OIM base repair rate	1
16	OIMDDR	OIM depot demand rate	1
17	CNDB	Base condemnation percent	1
18	CNDDO	Depot overhaul condemnation percent	1
19	NUSR	Number of users	1
20	PRESTK	Prestocked requirement	1
21	SLNEG	Negotiated base stock level	1
22	PWRM	Prepositioned war reserve material	13
23	FMS	Foreign military sales	29
24	OTHAD	Other additive requirements	14-32
25	SVCOH	Serviceable on-hand assets	42
26	DUEINS	Due-in serviceable assets	12
27	DUEINO	Due-in on-order assets	12
28	TOCAS	Technical order compliance assets	42
29	UNSVC	Carcass backlog	42
30	DUEINU	Due-in unserviceable assets	12
31	BASCD(j)	Base condemnations, jth past quarter	5
32	DEPCD(j)	Depot condemnations, jth past quarter	8
33	OVHCD(j)	Overhaul condemnations, jth past quarter	10
34	QPA	Quantity per application	50
35	APP	Application percentage	50

Altogether, 4905 items will be considered having application to the C-5; 4318 items having application to the F-15; and 1858 items having application to the F-16. Included within these categories are items common to several weapon systems, items peculiar to only one system, LRUs, and SRUs.

CUMULATIVE BUY REQUIREMENTS PER ITEM

Let the index w refer to a particular weapon system, which in this appendix may be either the C-5, F-15, or F-16 aircraft. Let the index t refer to a particular fiscal year, which may be any year from 1975 through 1984. And let the index i refer to a particular item or component.

Define

ASS(w,i) = total assets (serviceable, net unserviceable, due-in, and on order) associated with weapon system w for item i at asset cutoff in the first year that this item is stocked

ACT(w,t,i) = actual condemnations (base and depot) associated with weapon system w for item i from asset cutoff in its first year through asset cutoff in year t

PRO(w,t,i) = projected condemnations associated with weapon system w for item i because of operating requirements (organizational intermediate maintenance and depot level maintenance) from asset cutoff in year t through the end of the buy period (end of fiscal year plus procurement leadtime)

LEV(w,t,i) = level requirements (base and depot pipelines, safety stock, etc.) associated with weapon system w for item i at end of buy period following asset cutoff in year t

ADD(w,t,i) = additive requirements (war reserve material, etc.) associated with weapon system w for item i at end of buy period following asset cutoff in year t.

delim \$\$ It follows that the cumulative buy requirements associated with weapon system w for item i through fiscal year t can be computed with

$$\begin{aligned} CBR(w,t,i) = MAX\{&ACT(w,t,i) + PRO(w,t,i) + LEV(w,t,i) \\ &+ ADD(w,t,i) - ASS(w,i);\ CBR(w,t-1,i)\}, \end{aligned}$$

which is a nondecreasing function of time. Next, formulas for computing each of the elements in this formula will be given in terms of the input factors listed in Table B.1.

TOTAL ASSETS PER ITEM

Allocating the assets of common items to a given weapon system requires a complex process, because a given item could have multiple applications with different indenture levels. Define

$TP(w,t,i)$ = number of item-flying hours for item i on weapon system w in fiscal year t

$QPA(t,i,j)$ = quantity per application for a direct application of item i on next higher assembly j in year t

$APP(t,i,j)$ = application fraction for a direct application of item i on next higher assembly j in year t

$H(w,t)$ = total flying hours for weapon system w in year t.

The values for $QPA(t,i,j)$ are available from record 50 of the D041 database. Values for $H(w,t)$ for various years, were obtained from Ref. 8 and various other Air Force sources.

It follows that

$$\begin{aligned} TP(w,t,i) = &QPA(t,i,w) \bullet APP(t,i,w) \bullet H(w,t) \\ &+ \sum_j QPA(t,i,j) \bullet APP(t,i,j) \bullet TP(w,t,j) \end{aligned}$$

for each weapon system w, year t, and item i. Because this equation must be written for each year and each item in a given weapon system, a set of simultaneous linear equations is defined for the weapon system.

However, these equations have a special structure that can be exploited: if QPA(i,j) > 0, then QPA(j,i) = 0; and if QPA(i,j) > 0 and QPA(j,m) > 0, then QPA(m,i) = 0. As a result, and assuming that there are no errors in the data, it can be shown that the set of equations for each weapon system has a triangular structure.

A computer algorithm was developed that takes advantage of the triangular structure of this problem, so that the computation for each item requires the solution of only a single equation with a single unknown. After TP(m,t,i) is computed for all weapon systems m, years t, and items i, then the fraction of assets for common item i associated with weapon system w in year t can be computed with

$$\mathrm{PERCOM}(w,t,i) = \mathrm{TP}(w,t,i)/\sum_{m} \mathrm{TP}(m,t,i).$$

For example, if item i were peculiar to weapon system w, then PERCOM(w,t,i) = 1.0; but if item i were common to several weapon systems, then PERCOM(w,t,i) < 1.0.

The aggregate quantity per application for item i on weapon system w in year t can be computed with

$$\mathrm{AQPA}(w,t,i) = \mathrm{TP}(w,t,i)/\mathrm{H}(w,t).$$

While QPA(t,i,j) refers to the quantity per application on the next higher assembly, AQPA(w,t,i) refers to the total quantity of item i on the weapon system.

The available assets for an item can be placed in two categories: serviceable and unserviceable. The serviceable assets include:

SVOH(t,i) = serviceable base and depot assets for item i at asset cutoff in year t

DUEINS(t,i) = due-in serviceable assets for item i at asset cutoff in year t

DUEINO(t,i) = due-in on-order assets for item i at asset cutoff in year t

TOCAS(t,i) = technical order compliance assets for item i at asset cutoff in year t.

The unserviceable assets include:

UNSVC(t,i) = unserviceable base and depot assets for item i at asset cutoff in year t

DUEINV(t,i) = due-in unserviceable assets for item i at asset cutoff in year t.

The factor CNDDO(t,i) is the fraction of the unserviceable assets that can not be repaired. Thus the net initial assets for item i associated with weapon system w are

$$\begin{aligned} ASS(w,i) = {} & PERCOM(w,s,i)\{SVOH(s,i) + DUEINS(s,i) \\ & + DUEINO(s,i) + TOCAS(s,i) \\ & + [1 - CNDDO(s,i)][UNSVC(s,i) \\ & + DUEINU(s,i)]\}, \end{aligned}$$

where s is the first year for which item i is stocked, and PERCOM(w,s,i) is the fraction of the total assets that is associated with weapon system w.

ACTUAL CONDEMNATIONS PER ITEM

The D041 condemnation data consist of records 5, 8, and 10. As indicated in Table A.2, the asset cutoff date for the condemnation data available to this study varies from year to year, and this date is either 30 June or 30 September. Define the factors:

BASCD(j,t,i) = base condemnation of item i for the jth quarter past asset cutoff in year t-1

DEPCD(j,t,i) = depot condemnations of item i for the jth quarter past asset cutoff in year t-1

Thus, for weapon system w, the actual condemnations of item i from cutoff in its first year through asset cutoff in year t is

$$ACT(w,t,i) = \sum_{y=s+1}^{t} \sum_{j=1}^{J(y)} \{PERCOM(w,y,i) \; [BASCD(j,y,i) + DEPCD(j,y,i)]\}$$

where s is the initial year that item i is stocked, J(y) is the number of quarters between asset cutoff in year y-1 and the cutoff in year y, and PERCOM(w,y,i) is again used to determine the fraction of the total condemnations that is associated with weapon system w.

PROJECTED CONDEMNATIONS PER ITEM

The three weapon systems being considered are the C-5, F-15, and F-16 aircraft. For the purposes of computing the projected condemnations per item, it is necessary to know the annual flying hours for each of these aircraft. Table B.2 presents the historical flying hours for the C-5, F-15, and F-16 aircraft during fiscal years 1975 through 1984, and the projected values during fiscal years 1985 through 1987.

The procurement leadtime for an item is the sum of the administrative leadtime plus production leadtime. For a particular date of asset cutoff and item, the end of the buy period is the end of the fiscal year plus the procurement leadtime. Define

F(t) = fraction of the fiscal year remaining after asset cutoff in year t (1/4 if cutoff data is June 30, or 0 if cutoff is September 30)

ALT(t,i) = administrative leadtime for item i in year t

PLT(t,i) = production leadtime for item i in year t.

Both of these leadtimes are scaled to have units of years. It is

Table B.2

FLYING HOUR PROGRAM

Fiscal Year	Type	C-5	F-15	F-16
1975	historical	50309	2983	71
1976	historical	42134	8916	226
1977	historical	49388	36657	706
1978	historical	48281	62759	1244
1979	historical	48654	89601	3782
1980	historical	51142	107846	22888
1981	historical	52251	126711	46295
1982	historical	53045	149614	95840
1983	historical	54348	163936	137947
1984	historical	59479	175338	193883
1985	projected	57832	185564	222161
1986	projected	59821	192612	252692
1987	projected	64649	204519	282501

SOURCE: Department of the Air Force, Headquarters United States Air Force, *USAF Flying Hours, Landings, Sorties by Organization*, 1978-1984.

convenient to use the notation that $[Z]^+$ is the largest integer less than or equal to z. Define

$$Y(t,i) = [ALT(t,i) + PLT(t,i)]^+$$

and

$$R(t,i) = ALT(t,i) + PLT(t,i) - Y(t,i).$$

Thus the total flying hours for weapon system w from asset cutoff in year t through the end of the buy period for item i can be computed as

$$FH(w,t,i) = F(t) \bullet H(w,t) + \sum_{y=t+1}^{t+Y(t,i)} H(w,y) + R(t,i) \bullet H[w,Y(t,i) + 1],$$

where $H(w,t)$ is the total flying hours for weapon system w in year t. Define

$$OIMBRR(t,i) = \text{OIM base repair rate for item } i \text{ in year } t$$

$$CNDB(t,i) = \text{base condemnation fraction for item } i \text{ in year } t$$

Thus the projected OIM base condemnations associated with weapon system w for item i from asset cutoff in year t through the end of the buy period are

$$PBAS(w,t,i) = FH(w,t,i) \bullet AQPA(w,t,i) \bullet OIMBRR(t,i) \bullet CNDB(t,i),$$

where $AQPA(w,t,i)$ was defined earlier as being the total quantity of item i installed on weapon system w in year t.

Similarly, define

$$OIMDDR(t,i) = \text{OIM depot demand rate for item } i \text{ in year } t$$

$$CNDDO(t,i) = \text{depot overhaul condemnation fraction for item } i \text{ in year } t$$

It follows that the projected OIM depot condemnations for item i are

$$POIM(w,t,i) = FH(w,t,i) \bullet AQPA(w,t,i) \bullet OIMDDR(t,i) \bullet CNDDO(t,i).$$

In addition to OIM depot condemnations, other types of condemnations can also occur at the depot level because of the following depot level maintenance programs: MISTR (management of items subject to repair); PDM (programmed depot maintenance); and EOH (engine overhaul). In all three of these programs, the maintenance is divided into two portions: job-routed, removals that are job-routed for local repair; and nonjob-routed, removals that are turned into supply for shipment to another repair facility.

Define

OVHCD(j,t,i) = overhaul condemnations of item i for the jth quarter past asset cutoff in year t-1,

which is also available from the D041 databank.
The quantity OVHCD(j,t,i) can be interpreted as referring to all condemnations occurring at the depot echelon, excluding condemnations of items that were job-routed. Thus the difference

DEPCD(j,t,i) - OVHCD(j,t,i)

can be interpreted as being the total condemnations of items that were job-routed.

Our approach is to estimate

JRFH(w,t,i) = average number of job-routed condemnations of item i per item-flying hour associated with weapon system w, between the asset cutoff in year t-1 and the cutoff in year t

and

OVFH(w,t,i) = average number of overhaul condemnations of item i per item-flying hour associated with weapon system w, between the asset cutoff in year t-1 and the cutoff in year t.

When the asset cutoffs coincide with the beginning and ending of the fiscal year, then these quantities can be computed with

$$\mathrm{JRFH}(w,t,i) = \left\{ \sum_{j=1}^{4} [\mathrm{DEPCD}(j,t,i) - \mathrm{OVHCD}(j,t,i)]\mathrm{PERCOM}(w,t,i) \right\} / H(w,t)$$

and

$$\text{OVFH}(w,t,i) = \left\{ \sum_{j=1}^{4} \text{OVHCD}(j,t,i) \quad \text{PERCOM}(w,t,i) \right\} / \text{H}(w,t).$$

When the asset cutoffs do not coincide with the beginning and ending of the fiscal year, then the appropriate formulas are similar but more complex.

The total projected depot condemnations associated with weapon system w for item i from asset cutoff in year t through the end of the buy period are

$$\text{PDEP}(w,t,i) = \text{FH}(w,t,i) \bullet \text{AQPA}(w,t,i)\{\text{JRFH}(w,t,i)$$

$$+ \text{MAX}[\text{OIMDDR}(t,i) \bullet \text{CNDDO}(t,i),\ \text{OVFH}(w,t,i)]\},$$

where the second term is at least as large as the quantity POIM(w,t,i) defined earlier. Consequently, the total projected condemnations for both base and depot echelons are

$$\text{PRO}(w,t,i) = \text{PBAS}(w,t,i) + \text{PDEP}(w,t,i).$$

LEVEL REQUIREMENTS PER ITEM

For a particular date of asset cutoff and item, the end of the buy period is the end of the fiscal year plus the procurement leadtime; and the buy year is the particular fiscal year in which the end of the buy period falls. Define

$$\text{B}(t,i) = \begin{cases} \text{Y}(t,i) + 1 & \text{if} \quad \text{R}(t,i) > 0 \\ \text{Y}(t,i) & \quad\quad \text{R}(t,i) = 0, \end{cases}$$

where both Y(t,i) and R(t,i) were defined earlier in terms of the procurement leadtime. It follows that

$$BFH(w,t,i) = H[w,t+B(t,i)]$$

is the total flying hours for weapon system w during the buy year for item i following asset cutoff in year t.

The level requirements include the pipelines and safety levels during the buy year at both the base and depot echelons. Define

$$BRLD(t,i) = \text{base repair cycle for item i in year t}$$

$$BOSTD(t,i) = \text{base order and shipment time for item i in year t}$$

$$OIMDDR(t,i) = \text{OIM depot demand rate for item i in year t}$$

$$OIMBRR(t,i) = \text{OIM base repair rate for item i in year t.}$$

Thus the base repair pipeline, associated with weapon system w, for item i in year t is

$$\begin{aligned} BPIP(w,t,i) = {} & BFH(w,t,i) \bullet AQPA(w,t,i)\{BRCD(t,i) \bullet OIMBRR(t,i) \\ & + BOSTD(t,i)[OIMDDR(t,i) + CNDB(t,i) \bullet OIMBRR(t,i)]\}. \end{aligned}$$

This pipeline actually consists of two segments: the base repair pipeline and the order and shipment pipeline from the depot to the base.

The safety level is additional stock that provides protection in case the demand exceeds the average projection. Two different types of base safety levels are currently used in the D041 system: fixed, which is computed independently of an item's price; and variable, which is developed through a cost effectiveness technique called marginal analysis that varies according to greatest need subject to an item's price and a budget constraint. In the current system, the type of safety level used for each item is determined by the ERRC (expendability, recoverability, reparability, and cost) code for that item: Fixed safety levels are used for items having XDI as the ERRC code assignment, and variable safety levels are used for items having XD2 and XD3 as the code assignment. However, before June 1976, all items had fixed safety levels. Because we wish to investigate the value of having a requirements methodology that is uniform over all ten years from 1975 through 1984, it is assumed for the purposes of this appendix that all items have fixed OIM base safety levels for all years.

Define

$$NUSR(t,i) = \text{number of users of item in year } t.$$

The formula used in D041 for computing the fixed base safety level for item i in year t is

$$BSL(w,t,i) = NUSR(t,i) \bullet SQRT[2.3\ BPIP(w,t,i)/NUSR(t,i)],$$

where SQRT( ) is the square root function.

Next, consider the depot echelon. Define

$$TDRCD(t,i) = \text{total depot repair cycle for item } i \text{ in year } t$$

$$OIMDDR(t,i) = \text{OIM depot demand rate for item } i \text{ in year } t.$$

Thus the OIM depot pipeline for item i in year t is computed as

$$DPIP(w,t,i) = BFH(w,t,i) \bullet AQPA(w,t,i) \bullet TDRCD(t,i) \bullet OIMDDR(t,i).$$

As in the base case, two different types of depot safety levels are currently used in the D041 system: fixed, and variable. The fixed depot safety level is used in the initial cycle of computations, but it is not used in the final cycle for any item. The variable level, however, is used in the final cycle for items having XD2 and XD3 as ERRC code assignment, while no depot safety level is authorized for items having XD1 as the code assignment. However, before June 1976, only the fixed safety level was used in the final cycle for all items. To investigate the value of having a requirements methodology that is uniform over all ten years, it is assumed for the purposes of this appendix that all items have fixed OIM depot safety levels for all years.

Define

$$OIMSLD(t,i) = \text{fixed OIM depot safety stock level in years.}$$

Thus the OIM depot safety stock level for item i in year t is

$$DSL(w,t,i) = BFH(w,t,i) \bullet AQPA(w,t,i) \bullet OIMDDR(t,i) \bullet OIMSLD(t,i),$$

where $OIMSLD(t,i) = 0$ for items having XD1 as the ERRC code assignment, and $OIMSLD(t,i) = 1/12$ for items having XD2 or XD3 as the code assignment. The latter value corresponds to one month of projected demands.

There are three depot level maintenance programs: MISTR, PDM, and EOH. These programs are divided into two portions, job-routed and nonjob-routed, and a separate stock level is required for each portion.

As defined earlier, $JRFH(t,i)$ is the average number of job-routed condemnations for item i per item-flying hour between asset cutoff in year t-1 and the cutoff in year t. Define the D041 factor

$$SLDJR(t,i) = \text{job-routed stock level expressed in years.}$$

The job-routed stock level represents the amount of stock required to replace job-routed condemnations for a specified time period. This level is computed as

$$JRSL(w,t,i) = BFH(w,t,i) \bullet AQPA(w,t,i) \bullet JRFH(w,t,i) \bullet SLDJR(t,i).$$

The number of condemnations for nonjob-routed items is approximately equal to the total overhaul condemnations less the OIM depot condemnations. Thus the average number of nonjob-routed condemnations of item i per item-flying hour associated with weapon system w between asset cutoff in year t-1 and cutoff in year t is approximately

$$NJRFH(w,t,i) =$$

$$MAX[0,\ OVFH(w,t,i) - OIMDDR(t,i) \bullet CNDDO(t,i)],$$

where the individual components of this formula were defined earlier.

Define the D041 factor

$$SLDNJR(t,i) = \text{nonjob-routed stock level expressed in years.}$$

The nonjob-routed stock level represents the amount of stock required to replace units projected to be removed and turned in to supply, as unserviceable, for a specified time period. This level is computed as

$$NJRSL(w,t,i) =$$

$$EFH(w,t,i) \bullet AQPA(w,t,i) \bullet NJRFH(w,t,i) \bullet SLDNJR(t,i)/CNDDO(t,i),$$

where CNDDO(t,i) is used to convert condemnations into removals.

D041 also incorporates two additional stock levels into its requirements computations:

SLNEG(t,i) = the negotiated base stock level, which is an additional amount of stock for item i that is negotiated by the bases for year t

DFLSL(t,i) = the depot floating stock level, which represents the amount of stock for item i required by organic repair during year t.

Both of these levels should be multiplied by PERCOM(w,t,i) to obtain the amount associated with weapon system w in year t.

Consequently, the total level requirements associated with weapon system w for item i are

$$LEV(w,t,i) = BPIP(w,t,i) + BSL(w,t,i) + DPIP(w,t,i)$$

$$+ SDL(w,t,i) + JRSL(w,t,i) + NJRSL(w,t,i)$$

$$+ PERCOM(w,t,i)[SLNEG(t,i) + DFLSL(t,i)].$$

ADDITIVE REQUIREMENTS PER ITEM

It is also necessary to include the additive requirements, such as:

PWRM(t,i) = prepositioned war reserve material for item i in year t

PRESTK(t,i) = other war reserve material for item i in year t

FMS(t,i) = foreign military sales for item i in year t

OTHAD(t,i) = other additive requirements for item i in year t.

These requirements should be multiplied by the factor PERCOM(w,t,i), so that only the portion applicable to the given weapon is included. Thus the total additive requirements associated with weapon system w for item i in year t are

$$ADD(w,t,i) = PERCOM(w,t,i)[PWRM(t,i)$$

$$+ PRESTK(t,i) + FMS(t,i) + OTHAD(t,i)].$$

AGGREGATED CUMULATIVE BUY REQUIREMENTS

The formulas in the preceding sections enable the cumulative buy requirements CBR(w,t,i) to be computed for weapon system w, fiscal year t, and item i. The final step is to aggregate these requirements as described next.

Historical inflation indices for aircraft components are listed in Table B.3 for fiscal years 1975 through 1984. These indices can be used to convert the historical price for an item into constant dollars of a future year. Define

PRICE(t,i) = unit price in year t for item i in 1985 dollars.

Our computer code determines PRICE(t,i) in two different ways. The first method begins with the historical price of the item for the first year that the item is stocked, converts that price into 1985 dollars, and then uses that converted price for all subsequent years. With this

Table B.3

HISTORICAL AIRCRAFT COMPONENT INFLATION INDICES

	Airframe		Engine		Avionics		Overall	
FY	Index	% Growth	Index	% Growth	Index	% Growth	Index	% Growth
1975	.489	14.1	.495	16.5	.604	10.3	.513	13.6
1976	.530	8.4	.538	8.7	.622	3.0	.550	7.2
1977	.571	7.7	.581	7.9	.647	4.0	.588	6.9
1978	.617	8.0	.630	8.4	.675	4.4	.631	7.3
1979	.678	9.8	.707	12.2	.715	6.0	.691	9.5
1980	.755	11.4	.826	16.9	.781	9.3	.774	12.0
1981	.843	11.6	.930	12.6	.846	8.3	.861	11.2
1982	.906	7.5	.959	3.1	.906	7.1	.917	6.5
1983	.955	5.4	.966	0.7	.960	6.0	.959	4.6
1984	1.000	4.7	1.000	3.5	1.000	4.2	1.000	4.3

SOURCE: Ref. 10.

first approach, PRICE(t,i) is invariant with respect to the year t. The second method begins with the historical price of the item for any year t, converts that price into 1985 dollars, and then uses that converted price for PRICE(t,i). With this second approach, PRICE(t,i) does vary with respect to the year t.

The aggregate cumulative buy requirements for weapon system w and the asset cutoff in fiscal year t is given by

$$\mathrm{ACBR}(w,t) = \sum_{i \in w} \mathrm{PRICE}(t,i) \bullet \mathrm{CBR}(w,t,i),$$

where the summation is over all items included within that weapon system. Tables B.4, B.5, and B.6 provide the aggregate cumulative buy requirements, in 1985 dollars, for the C-5, F-15, and F-16 aircraft respectively. In the case of these and other tables given in the remainder of this section, the first method of determining converted prices is used, so that the converted price for each item is constant over time. The cumulative buy requirements listed in these tables are for fiscal years 1975 through 1984, and they are broken down according to the various elements described in earlier sections.

Tables B.4-B.6 include an entry called "excess inventory." This entry for a particular year refers to that portion of the cumulative buy requirements that was needed for previous years but is no longer needed, perhaps because some items were modified or because other items were phased out. The excess inventories given in these tables are much higher than would be produced by a more realistic D041 computation because if an item is to be modified or phased out, the factors listed in Table B.1 for that item should change in the future. Consequently, each year D041 allows an equipment specialist to anticipate these future changes by specifying both current factor values and forecast values for one, two, or three years in the future. However, for the purposes of computing projected condemnations and level requirements, the simplified D041 formulas discussed in this appendix assume that these factors do

Table B.4

CUMULATIVE BUY REQUIREMENTS FOR C-5 AIRCRAFT

TOTAL UNITS FOR END ITEM C005 FSC 0

CUMULATIVE BUY REQUIREMENTS FOR END ITEM C005 (THOUSANDS OF DOLLARS)

FISCAL YEAR:	<-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
TOTAL PROJ BASE CNDMNS	861.	265.	186.	1641.	1696.	489.	280.	246.	123.	50.
PROJ OIM DEPOT CNDMNS	10560.	9942.	13573.	12570.	12754.	13859.	11992.	18082.	8881.	8491.
PROJ NJR CNDMNS	2305.	4766.	6004.	8240.	8788.	7750.	8204.	3263.	3841.	5276.
TOTAL PROJ OH CNDMNS	12864.	14709.	19577.	20809.	21542.	21609.	20196.	21345.	12722.	13767.
TOTAL PROJ JR CNDMNS	868.	1861.	3348.	6817.	7055.	5805.	5124.	8925.	4748.	6650.
OIM BASE PIPELINE	24141.	27062.	29776.	22491.	22847.	27526.	22817.	28190.	22377.	21910.
OIM BASE SAFETY LEV	39385.	51436.	54155.	50975.	51[illegible]37.	52935.	49190.	54479.	45669.	47250.
NEGOTIATED BASE S/L	44983.	26659.	29033.	8750.	8730.	13488.	9244.	9624.	3445.	3467.
OIM DEPOT PIPELINE	54370.	54393.	62433.	65896.	66749.	74287.	42636.	48074.	46042.	44953.
OIM DEPOT SAFETY LEV	32613.	36287.	39640.	34197.	34457.	45650.	26063.	28547.	27350.	27394.
DEPOT NJR PIPELINE	2367.	1479.	1831.	2716.	2987.	2517.	1643.	1424.	908.	1350.
DEPOT JR PIPELINE	0.	0.	0.	100.	103.	64.	83.	132.	73.	99.
DEPOT FLOATING S/L	159.	104.	4411.	2885.	2885.	6683.	6197.	5191.	3941.	3737.
TOTAL LEVEL REQUIREMENTS	198019.	197420.	221279.	188011.	190293.	233151.	157874.	175661.	149806.	150159.
PREPOS WRM RQMTS	122109.	130501.	131376.	180516.	218682.	227709.	226495.	213808.	179770.	197896.
OTHER WRM RQMTS	460845.	495080.	441489.	251980.	251105.	245337.	185027.	352185.	129564.	149493.
OTHER ADDITIVE RQMTS	5143.	5162.	5277.	1849.	8852.	40455.	47498.	47437.	67918.	40961.
TOTAL ADDITIVE RQMTS	588097.	630743.	578142.	434346.	478638.	5[illegible]3501.	459019.	613430.	377251.	388350.
CUM BASE CNDMNS	0.	592.	1252.	1499.	1749.	2086.	10562.	10771.	10930.	11089.
CUM OH CNDMNS	0.	3811.	10658.	17770.	24919.	32560.	43667.	47816.	52152.	56242.
CUM JR CNDMNS	0.	1104.	2861.	5410.	7990.	10434.	12937.	16106.	17856.	20268.
TOTAL CUM CONDEMNATIONS	0.	5507.	14772.	24679.	34659.	45079.	67166.	74693.	80938.	87600.
INITIAL SERV ASSETS	270303.	281902.	288580.	291305.	291314.	301235.	303275.	314182.	330455.	344920.
INITIAL DUEIN ASSETS	30711.	37272.	37272.	37272.	37351.	41174.	41945.	42145.	52384.	55585.
INITIAL NET UNSERV	205329.	216595.	222697.	225889.	225889.	227820.	229135.	240803.	246291.	253743.
TOTAL INITIAL ASSETS	506343.	535769.	548549.	554465.	554554.	570228.	574356.	597130.	629130.	654248.
TOTAL EXCESS INVENTORY	99174.	238419.	387683.	579564.	556202.	648481.	742518.	712095.	1013286.	1043636.
CUMULATIVE BUY REQUIREMENTS	393541.	578019.	704506.	772668.	811146.	996007.	1045342.	1211793.	1262039.	1295926.

TOTAL NUMBER OF ITEMS- 4905

Table B.5

CUMULATIVE BUY REQUIREMENTS FOR F-15 AIRCRAFT

TOTAL UNITS FOR END ITEM F015 FSC 0

CUMULATIVE BUY REQUIREMENTS FOR END ITEM F015 (THOUSANDS OF DOLLARS)

FISCAL YEAR:	<-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
TOTAL PROJ BASE CNDMNS	913.	21.	1592.	764.	931.	1880.	1029.	577.	770.	607.
PROJ OIM DEPOT CNDMNS	42535.	54477.	38145.	34872.	55653.	225461.	109389.	93929.	77250.	88577.
PROJ NJR CNDMNS	0.	9.	176.	511.	408.	3063.	6196.	9920.	7336.	6028.
TOTAL PROJ OH CNDMNS	42535.	54486.	38321.	35382.	56061.	228524.	115584.	103849.	84585.	94605.
TOTAL PROJ JR CNDMNS	0.	0.	17652.	7947.	6826.	8272.	4403.	92390.	31846.	7932.
OIM BASE PIPELINE	144131.	128953.	155669.	107315.	120181.	167390.	168138.	174385.	168012.	148245.
OIM BASE SAFETY LEV	76498.	115741.	158964.	130756.	136871.	167223.	196996.	210752.	203282.	210596.
NEGOTIATED BASE S/L	31962.	56491.	15124.	5775.	5808.	33741.	71365.	52058	16788.	3745.
OIM DEPOT PIPELINE	224032.	310762.	269445.	272050.	302649.	415984.	317531.	312324.	298194.	292215.
OIM DEPOT SAFETY LEV	134391.	189267.	196874.	182478.	199370.	223555.	178372.	174961.	175806.	162583.
DEPOT NJR PIPELINE	0.	11.	666.	376.	469.	807.	1762.	3209.	1843.	2917.
DEPOT JR PIPELINE	0.	0.	0.	192.	159.	135.	84.	81.	123.	101.
DEPOT FLOATING S/L	155.	159.	736.	1816.	1816.	4393.	7660.	8336.	6603.	5637.
TOTAL LEVEL REQUIREMENTS	611168.	801386.	797478.	700756.	767523.	1013177.	941907.	936106.	870650.	826039.
PREPOS WRM RQMTS	101575.	302804.	154686.	314503.	455913.	839049.	1110264.	795127.	706095.	769198.
OTHER WRM RQMTS	22023.	12797.	213081.	274903.	274186.	227487.	70971.	254502.	230897.	299752.
OTHER ADDITIVE RQMTS	9851.	20611.	23644.	25116.	135545.	131770.	179304.	374364.	314319.	365960.
TOTAL ADDITIVE RQMTS	133449.	336211.	391411.	614522.	865644.	1198306.	1360540.	1423993.	1251311.	1434910.
CUM BASE CNDMNS	0	8	467.	524.	1191.	2951.	5258.	7321.	9392.	10929.
CUM OH CNDMNS	0	3.	139.	493.	1216.	5070.	16930.	26831.	38392.	48298.
CUM JR CNDMNS	0.	0.	4731.	7251.	9926.	12178.	14377.	44009.	58135.	61986.
TOTAL CUM CONDEMNATIONS	0.	11.	5337.	8268.	12333.	20200.	36566.	78161.	105919.	121213.
INITIAL SERV ASSETS	28958.	73624.	111653.	185309.	185333.	455250.	509278.	547537.	562723.	587769.
INITIAL DUEIN ASSETS	260727.	596088.	597117.	597321.	598567.	783460.	842253.	926519.	946696.	976387.
INITIAL NET UNSERV	5556.	20090.	51893.	97629.	97653.	190578.	218908.	261142.	275973.	290490.
TOTAL INITIAL ASSETS	295242.	689803.	760663.	880259.	881553.	1429288.	1570439.	1735597.	1785392.	1854646.
TOTAL EXCESS INVENTORY	50802.	457339.	883530.	1147698.	1090128.	1832022.	2358922.	2832006.	3306021.	3504189.
CUMULATIVE BUY REQUIREMENTS	543625.	968658.	1423375.	1938774.	2223289.	3255935.	3702506.	4321374.	4553678.	4849310.

TOTAL NUMBER OF ITEMS 4318

Table B.6

CUMULATIVE BUY REQUIREMENTS FOR F-16 AIRCRAFT

TOTAL UNITS FOR END ITEM F016 FSC= 0

CUMULATIVE BUY REQUIREMENTS FOR END ITEM F016 (THOUSANDS OF DOLLARS)

FISCAL YEAR:	<-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
TOTAL PROJ BASE CNDMNS	0.	0.	18.	66.	170.	697.	20.	156.	19.	151.
PROJ OIM DEPOT CNDMNS	0.	5.	1841.	9113.	24147.	22567.	7163.	110039.	56843.	68869.
PROJ NJR CNDMNS	0.	0.	3.	6.	11.	6.	140.	1898.	2593.	1524.
TOTAL PROJ OH CNDMNS	0.	5.	1844.	9120.	24158.	22574.	7302.	111938.	59436.	70393.
TOTAL PROJ JR CNDMNS	0.	0.	0.	0.	12.	24.	1172.	340.	2280.	1287.
OIM BASE PIPELINE	0.	8.	11323.	26360.	58268.	59646.	53484.	53974.	59409.	79846.
OIM BASE SAFETY LEV	1.	119.	9103.	17855.	25555.	45143.	58197.	62947.	78048.	95001.
NEGOTIATED BASE S/L	0.	0.	15.	137.	138.	68113.	94744.	78282.	95491.	31076.
OIM DEPOT PIPELINE	0.	28.	43361.	85695.	191505.	160629.	147886.	163032.	180138.	282863.
OIM DEPOT SAFETY LEV	0.	17.	28006.	57107.	128660.	96895.	86790.	82836.	77945.	120990.
DEPOT NJR PIPELINE	0.	0.	2.	3.	6.	3.	110.	280.	296.	253.
DEPOT JR PIPELINE	0.	0.	0.	0.	1.	1.	22.	7.	14.	13.
DEPOT FLOATING S/L	0.	0.	0.	0.	0.	54.	126.	371.	721.	442.
TOTAL LEVEL REQUIREMENTS	2.	173.	91811.	187157.	404132.	430484.	441358.	441728.	492064.	610483.
PREPOS WRM RQMTS	0.	3.	6.	78.	102361.	403444.	736887.	680714.	620461.	758934.
OTHER WRM RQMTS	0.	115.	120465.	55083.	54206.	48316.	24969.	86536.	110643.	72153.
OTHER ADDITIVE RQMTS	0.	106.	117.	29.	26369.	461617.	58099.	65614.	293139.	325724.
TOTAL ADDITIVE RQMTS	0.	225.	120587.	55190.	182936.	913377.	819955.	832864.	1024243.	1156811.
CUM BASE CNDMNS	0.	0.	0.	0.	0.	40.	43.	344.	1097.	2047.
CUM OH CNDMNS	0.	0.	1.	3.	4.	136.	386.	2203.	4280.	8788.
CUM JR CNDMNS	0.	0.	0.	0.	0.	0.	120.	224.	475.	1028.
TOTAL CUM CONDEMNATIONS	0.	0.	2.	3.	5.	176.	550.	2771.	5852.	11863.
INITIAL SERV ASSETS	1.	55.	227.	249.	388.	41670.	78607.	96294.	185374.	237458.
INITIAL DUEIN ASSETS	0.	214.	270.	274.	388.	128024.	255016.	298852.	390779.	412655.
INITIAL NET UNSERV	0.	30.	60.	65.	86.	19629.	46075.	63063.	83217.	110004.
TOTAL INITIAL ASSETS	1.	299.	557.	588.	863.	189323.	379698.	458209.	659370.	760117.
TOTAL EXCESS INVENTORY	0.	62.	59.	68339.	28999.	443846.	1130605.	1318981.	1618564.	1827863.
CUMULATIVE BUY REQUIREMENTS	1.	166.	213826.	319434.	639746.	1622394.	2026879.	2265966.	2590684.	3015684.

TOTAL NUMBER OF ITEMS= 1850

not change and remain equal to their current values. For items being modified or phased out, this assumption would overestimate the projected condemnations and level requirements, resulting in excess inventories that are much higher than would be encountered in practice.

It is desirable to aggregate the cumulative buy requirements with respect to groups of federal stock classes, where each federal stock class in turn constitutes a group of items. Let the index g refer to a particular group of federal stock classes. Thus the aggregate cumulative buy requirements for items within group g included in weapon system w at the asset cutoff in fiscal year t is given by

$$ACBR(g,t) = \sum_{i \in g} PRICE(t,i) \bullet CBR(w,t,i),$$

where the summation is over to all items included within group g.

For example, Table B.7 defines 13 different groups, where each group consists of one or more federal stock classes. In terms of these definitions, Tables B.8, B.9, and B.10 provide the aggregate cumulative buy requirements, in 1985 dollars, for the C-5, F-15, and F-16 aircraft respectively. Each table provides both the aggregate cumulative buy requirements and number of items for each group and fiscal year. Altogether, 4905 items are considered for the C-5, 4318 items for the F-15, and 1858 items for the F-16. The number of items in each group is nondecreasing over time for two reasons: New items may be added to each weapon system during each successive year and items that are dropped must still have their cumulative buy requirements included within the aggregate total and therefore must still be included in the total item count.

Table B.7

GROUP AGGREGATION DATA

No.	FSC	Name
1	1005	Guns, through 30 MM
1	1095	Miscellaneous weapons
2	1270	Aircraft gunnery fire control components
2	1280	Aircraft bombing fire control components
3	1560	Aircraft structural components
4	1620	Aircraft landing gear components
4	1630	Aircraft wheel and brake systems
5	1650	Aircraft hydraulic, vacuum and de-icing system
5	1660	Aircraft air conditioning, heating and pressurizing
6	1680	Miscellaneous aircraft accessories and components
4	2620	Tires and tubes, pneumatic, aircraft
7	2835	Gas turbines and jet engines, except aircraft
7	2925	Engine electrical system components, aircraft
7	4810	Valves, powered
8	4920	Aircraft maintenance & repair shop specialized equip
9	5821	Radio and television communication equipment/airborne
9	5826	Radio navigation equipment, airborne
11	5841	Radar equipment, airborne
11	5865	Electronic countermeasure equipment
9	5895	Miscellaneous communications equipment, airborne
7	6110	Electrical control equipment
7	6115	Generators and generator sets, electrical
10	6605	Navigational instruments
10	6610	Flight instruments
13	6615	Automatic pilot mechanisms & airborne gyro comp
10	6620	Engine instruments
10	6710	Cameras, motion picture
12	7021	Automatic data processing central unit (CPU,computer)
12	7025	Automatic data processing input/output & storage dev

Table B.8

REQUIREMENTS AND DISTRIBUTION FOR C-5 AIRCRAFT,
BY AGGREGATION GROUP

TOTAL UNITS FOR END ITEM C005

CUMULATIVE BUY REQUIREMENTS FOR END ITEM C005 (THOUSANDS OF DOLLARS)

FSC	FISCAL YEAR: <-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
3	15488.	41165.	43779	45906.	49888.	54838.	66062.	80554.	105309.	105651.
4	28302.	36940.	42653.	52100.	59939.	80621.	94379.	110276.	112991.	121062.
5	14596.	24288.	26136.	43378.	47593.	68215.	69503.	82342.	82499.	83585.
6	10632.	15182.	20826.	24051.	26700.	27877.	28976.	33225.	35874.	37220.
7	7562.	11860.	14289.	15906.	16728.	19021.	19812.	24131.	24945.	25118.
8	29704.	49622.	75807.	96423.	107254.	110007.	110136.	168727.	168729.	168793.
9	32023.	43513.	52985.	57568.	63556.	66997.	71926.	86834	87240.	88672.
10	120563.	155437.	184861.	187211.	188156.	253104.	256195.	265696.	271064.	272614.
11	72896.	87914.	106119.	107221.	108272.	133996.	135136.	147558.	147896.	148319.
12	5191.	47128.	57559.	58170.	58177.	59404.	61410.	61416.	61430.	72342.
13	43516.	[illegible]	56615.	59679.	63001.	89485.	99288.	111663.	124177.	124953.
14	13083.	16471.	23272.	25013.	25873.	33033.	32529.	39357.	39871.	47585.
TOTAL	393536.	578012.	704498.	772659.	811137.	975997.	1045330.	1211780.	1262025.	1295912.

DISTRIBUTION OF COMPONENTS FOR END ITEM C005

FSC	FISCAL YEAR: <-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
3	1948	2068	2075	2092	2092	2132	2133	2135	2137	2139
4	185	190	203	208	208	212	213	214	214	216
5	200	213	220	223	223	226	227	227	230	232
6	254	273	276	276	276	278	283	283	283	286
7	76	87	88	89	89	91	91	92	92	92
8	214	215	220	222	222	223	227	229	229	229
9	260	277	284	293	293	311	341	370	372	374
10	237	251	257	257	257	305	315	342	355	364
11	136	145	148	151	151	151	175	175	175	177
12	6	26	74	76	80	130	132	132	132	134
13	235	248	250	268	268	268	268	269	272	274
14	295	325	330	347	347	367	376	384	386	388
TOTAL	4066	4318	4425	4502	4506	4694	4781	4852	4877	4905

Table B.9

REQUIREMENTS AND DISTRIBUTION FOR F-15 AIRCRAFT, BY AGGREGATION GROUP

TOTAL UNITS FOR END ITEM F015

CUMULATIVE BUY REQUIREMENTS FOR END ITEM F015 (THOUSANDS OF DOLLARS)

FSC	FISCAL YEAR: <-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
1	0.	7.	17.	93.	213.	739.	853.	853.	853.	1213.
2	2273.	7639	17799.	21446.	29384.	35606	51162.	56641.	62885.	63279.
3	545.	65781.	67530	90885.	158215.	195888.	217440.	374189.	411463.	414933.
4	26248.	58591.	64017.	92395.	123647.	233682.	208426.	263435.	262283.	265760.
5	25106.	39858.	65538.	93580.	104386.	227585.	138759.	180470.	199567.	207608.
6	943.	1681.	2531.	4312.	6092.	8037.	10856.	12806.	16754.	18085.
7	7094.	35217.	58880.	81155.	87225.	95100.	107544.	141884.	162234.	179295.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	5985.	13829.	20650.	34094.	43639.	52878.	68300.	75520.	81974.	89955.
10	47962.	83288.	168403.	225350.	254748.	262061.	303606.	333407.	346519.	355097.
11	417078.	637487.	913012.	1233018.	1340995.	2010452.	2297743.	2579387.	2687691.	2875715.
12	145.	2002.	3334.	3368.	3604.	7813.	15840.	16542.	16645.	21935.
13	4823.	12554.	15637.	23559.	33020.	39266.	44548.	70572.	76121.	78261.
14	5408	10696.	25983.	35466.	38087.	186755.	197360.	217563.	227979.	278049.
TOTAL	543611.	968627.	1423331.	1938721.	2223235.	3255862	3702416.	4321268.	4553560.	4849181.

DISTRIBUTION OF COMPONENTS FOR END ITEM F015

FSC	FISCAL YEAR: <-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
1	0	3	3	3	3	3	4	4	6	6
2	62	110	120	145	145	177	178	178	181	181
3	240	359	430	490	493	537	576	579	590	601
4	39	52	59	68	68	71	91	92	94	95
5	151	191	218	221	221	238	247	252	254	257
6	67	80	93	113	115	123	125	127	127	129
7	133	183	207	213	213	227	229	233	235	236
8	0	0	0	0	0	1	1	1	1	1
9	135	156	172	190	192	259	298	313	354	360
10	330	416	450	472	472	491	510	524	529	550
11	592	671	719	764	764	967	997	1044	1067	1109
12	59	60	60	60	60	182	187	187	187	201
13	78	109	119	119	119	123	123	125	128	128
14	244	293	321	336	336	400	434	445	451	464
TOTAL	2130	2683	2969	3194	3201	3819	4000	4104	4204	4318

Table B.10

REQUIREMENTS AND DISTRIBUTION FOR F-16 AIRCRAFT,
BY AGGREGATION GROUP

TOTAL UNITS FOR END ITEM F016

CUMULATIVE BUY REQUIREMENTS FOR END ITEM F016 (THOUSANDS OF DOLLARS)

FSC	FISCAL YEAR: <-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
1	0.	2.	3.	12.	19.	19.	584.	7782.	7816.	9435.
2	0.	0.	95158.	125060.	250641.	515074.	641495.	670265.	713302.	824037.
3	0.	0.	530.	15592.	47135.	461419.	629707.	753560.	917826.	995835.
4	0.	0.	1350.	10063.	17335.	31653.	33831.	48936.	56807.	63342.
5	0.	0.	309.	1979.	4024.	25477.	28604.	30056.	35023.	40603.
6	0.	0.	1427.	17187.	25475.	75141.	86041.	95729.	102484.	118415.
7	0.	0.	23.	5420.	7752.	27500.	41183.	56187.	62836.	66986.
9	0	0.	449.	1419.	2484.	6365.	11372.	16795.	19860.	25235.
10	1.	4.	97210.	108597.	208483.	345393.	388628.	400278.	426937.	438267.
11	0.	153.	2735.	14565.	32707.	72335.	79387.	89297.	141943.	228772.
13	0.	7.	14631.	19434.	43355.	52144.	72953.	82448.	83177.	87004.
14	0.	0.	1.	155.	333.	9851.	13058.	14587.	22621.	117694.
TOTAL	1.	166.	213826.	319482.	639743.	1622369.	2026842.	2265920.	2590630.	3015624.

DISTRIBUTION OF COMPONENTS FOR END ITEM F016

FSC	FISCAL YEAR: <-- 1 -->	<-- 2 -->	<-- 3 -->	<-- 4 -->	<-- 5 -->	<-- 6 -->	<-- 7 -->	<-- 8 -->	<-- 9 -->	<--10 -->
1	0	4	6	8	8	9	13	14	14	14
2	0	0	8	39	39	165	225	231	245	279
3	0	1	33	95	95	130	149	165	180	187
4	0	0	7	24	24	50	61	66	75	82
5	0	1	8	30	30	50	51	54	60	61
6	0	0	7	49	49	87	99	105	115	126
7	0	0	3	45	46	84	90	98	108	111
9	0	0	31	41	41	103	135	140	161	166
10	1	7	25	53	53	148	171	185	190	201
11	0	36	61	100	101	151	162	170	326	361
13	0	2	8	17	17	42	56	64	77	83
14	1	2	6	55	55	105	122	131	168	187
TOTAL	2	53	203	556	558	1124	1334	1423	1719	1858

Appendix C

FEDERAL STOCK CLASSES

Federal Supply Class	Model, Type, or Materiel	AF IM	DLA Supply Center	Serviceable Supply Site
1005	Guns, through 30 mm	WR/MMI		WR
1010	Guns, over 30 mm up to 75 mm	WR/MMI		WR
1015	Guns, 75 mm through 125 mm	WR/MMI		WR
1020	Guns, over 125 mm through 150 mm	WR/MMI		WR
1025	Guns, 150 mm through 200 mm	WR/MMI		WR
1030	Guns, over 200 mm through 300 mm	WR/MMI		WR
1035	Guns, over 300 mm	WR/MMI		WR
1040	Chemical Weapons and Equipment	WR/MMI		WR
1045	Launchers, Torpedo and Depth Charge	WR/MMI		WR
1055	Launchers, Rocket and Pyrotechnic	WR/MMI		WR
1070	Nets and Booms, Ordnance	WR/MMI		WR
1075	Degaussing and Mine Sweeping Equipment	WR/MMI		WR
1080	Camouflage and Deception Equipment	WR/MMI		WR
1090	Assemblies Interchangeable between Weapons Classes	WR/MMI		WR
1095	Miscellaneous Weapons	WR/MMI		WR
1105	Nuclear Bombs	SA		SA
1110	Nuclear Projectiles	SA		SA
1115	Nuclear Warheads and Warhead Sections	SA		SA
1125	Nuclear Demolition Charges	SA		SA
1127	Nuclear Rockets	SA		SA
1130	Conversion Kits, Nuclear Ordnance	SA		SA
1135	Fuzing and Firing Devices, Nuclear Ordnance	SA		SA
1140	Nuclear Components	SA		SA
1145	High Explosive Charges, Propellants	SA		SA
1190	Specialized Test and Handling Equipment, Nuclear	SA		SA
1195	Miscellaneous Nuclear Ordnance	SA		SA
1210	Fire Control Directors	WR/MMI		WR
1220	Fire Control Computing Sights and Devices	WR/MMI		WR
1230	Fire Control Systems, Complete	WR/MMI		WR
1240	Optical Sighting and Ranging Equipment	WR/MMI		WR
1250	Fire Control Stabilizing Mechanisms	WR/MMI		WR
1260	Fire Control Designating and Indicating Equipment	WR/MMI		WR
1265	Fire Control Transmitting & Receiving--not Airborne	SM/MMC		SM
1270	Aircraft Gunnery Fire Control Components	WR/MMI		WR
1280	Aircraft Bombing Fire Control Components	WR/MMI		WR
1285	Fire Control Radar Equipment, except Airborne	WR/MMI		WR
1287	Fire Control Sonar Equipment	WR/MMI		
1290	Miscellaneous Fire Control Equipment	WR/MMI		WR

1305	Ammunition, through 30 mm	OO/MMW	OO
1310	Ammunition, over 30 mm up to 75 mm	OO/MMW	OO
1315	Ammunition, 75 mm through 125 mm	OO/MMW	OO
1320	Ammunition, over 125 mm	OO/MMW	
1325	Bombs (Nonnuclear)	OO/MMW	OO
1330	Grenades	OO/MMW	OO
1336	Guided Missile Warheads and Explosive--nonnuclear	OO/MMW	OO
1337	Guided Missile and Space Vehicle Explosive	OO/MMW	OO
1338	Guided Missile and Space Vehicle Inert	OO/MMW	OO
1340	Rockets and Rocket Ammunition	OO/MMW	OO
1345	Land Mines	OO/MMW	OO
1350	Underwater Mine Inert Components	OO/MMW	OO
1351	Underwater Mine Explosive Components	OO/MMW	OO
1355	Torpedo Inert Components	OO/MMW	
1356	Torpedo Explosive Components	OO/MMW	
1360	Depth Charge Inert Components	OO/MMW	
1361	Depth Charge Explosive Components	OO/MMW	
1365	Military Chemical Agents	OO/MMW	OO
1370	Pyrotechnics	OO/MMW	OO
1375	Demolition Materiel	OO/MMW	OO
1376	Bulk Explosives	OO/MMW	OO
1377	Cartridge and Propellant Activated Devices	OO/MMW	OO
1380	Military Biological Agents	OO/MMW	OO
1385	Explosive Ordnance Disposal Tools, Surface	OO/MMW	OO
1386	Explosive Ordnance Disposal Tools, Underwater	OO/MMW	OO
1390	Fuzes and Primers	OO/MMW	OO
1395	Miscellaneous Ammunition	OO/MMW	OO
1398	Specialized Ammunition Handling and Servicing Equip	OO/MMW	OO
1410	Guided Missiles	OO/MMC	
1420	Guided Missile Components	OO/MMC	
1425	Guided Missile Systems, Complete	OO/MMC	
1427	Guided Missile Subsystems	OO/MMC	
1430	Guided Missile Remote Control Systems	OO/MMC	
1440	Launchers, Guided Missiles	OO/MMC	
1450	Guided Missile Handling and Servicing Equipment	OO/MMC	
1510	Aircraft, Fixed Wing	SM/MMI	SM
1520	Aircraft, Rotary Wing	WR/MMI	WR
1540	Gliders	SM/MMI	SM
1550	Drones	SM/MMI	SM
1560	Aircraft Structural Components	SM/MMI	SM
1610	Aircraft Propellers	WR	WR
1615	Helicopter Rotor Blades, Drive Mechanisms	WR/MMI	WR
1620	Aircraft Landing Gear Components	OO/MMI	OO
1630	Aircraft Wheel and Brake Systems	OO/MMI	OO
1650	Aircraft Hydraulic, Vacuum and De-Icing System	OC/MMI	OC
1660	Aircraft Air Conditioning, Heating and Pressurizing	OC/MMI	OC
1670	Parachutes and Aerial Pickup, Recovery Systems	SA/MMI	SA
1680	Miscellaneous Aircraft Accessories and Components	SA/MMI	SA
1710	Aircraft Arresting, Barrier, and Barricade	SA/MMI	SA
1720	Aircraft Launching Equipment	SA/MMI	SA
1730	Aircraft Ground Servicing Equipment	SA/MMI	SA

1740	Airfield Specialized Trucks and Trailers	SA/MMI		SA
1810	Space Vehicles	SM/MMI		SM
1820	Space Vehicle Components	SM/MMI		SM
1830	Space Vehicle Remote Control Systems	SM/MMI		SM
1840	Space Vehicle Launchers	SM/MMI		SM
1850	Space Vehicle Handling & Servicing Equipment	SM/MMI		SM
1860	Space Survival Equipment	SM/MMI		SM
1905	Combat Ships and Landing Vessels	SA/MMI		SA
1910	Transport Vessels, Passenger and Troop	SA/MMI		
1915	Cargo and Tanker Vessels	SA/MMI		SA
1920	Fishing Vessels	SA/MMI		
1925	Special Service Vessels	SA/MMI		SA
1930	Barges and Lighters, Cargo	SA/MMI		SA
1935	Barges and Lighters Special Purpose	SA/MMI		SA
1940	Small Craft	SA/MMI		SA
1945	Pontoons and Floating Docks	SA/MMI		
1950	Floating Drydocks	SA/MMI		
1955	Dredges	SA/MMI		SA
1990	Miscellaneous Vessels	SA/MMI		
2010	Ship and Boat Propulsion Components	SA/MMI		SA
2020	Rigging and Rigging Gear	SA/MMI		SA
2030	Deck Machinery	SA/MMI		SA
2040	Marine Hardware and Hull Items	SA/MMI		SA
2050	Buoys	SA/MMI		
2060	Commercial Fishing Equipment	SA/MMI		
2090	Miscellaneous Ship and Marine Equipment	SA/MMI		SA
2210	Locomotives	WR/MMI		USAMEC
2220	Rail Cars	WR/MMI		USAMEC
2230	Right-of-Way Construction & Maintenance--Railroad	WR/MMI	DC	USAMEC
2240	Locomotives and Rail Car Accessories	WR/MMI		USAMEC
2250	Track Materiel, Railroad	WR/MMI		USAMEC
2305	Ground Effect Vehicles	WR/MMI		
2310	Passenger Motor Vehicles	WR/MMI		WR
2320	Trucks and Truck Tractors	WR/MMI		WR
2330	Trailers	WR/MMI		WR
2340	Motorcycles, Motor Scooters, and Bicycles	WR/MMI		WR
2350	Combat Assault and Tactical Vehicles, Track	WR/MMI		WR
2410	Tractors, Full Track, Low Speed	WR/MMI	DC	WR
2420	Tractors, Wheeled	WR/MMI	DC	WR
2430	Tractors, Track Laying, High Speed	WR/MMI		WR
2510	Vehicular Cab, Body & Frame Structural Components	WR/MMI	DC/ATAC	WR
2520	Vehicular Power Transmission Components	WR/MMI	DC/ATAC	WR
2530	Vehicular Brake, Steering, Axle, Wheel	WR/MMI	DC/ATAC	WR
2540	Vehicular Furniture and Accessories	WR/MMI	DC/ATAC	WR
2590	Miscellaneous Vehicular Components	WR/MMI	DC/ATAC	WR
2610	Tires and Tubes, Pneumatic, except Aircraft	WR/MMI	ATAC	WR
2620	Tires and Tubes, Pneumatic, Aircraft	OO/MMI		OO
2630	Tires, Solid and Cushion	WR/MMI	ATAC	WR
2640	Tire Rebuilding & Tire & Tube Repair Materiel	WR/MMI	ATAC	WR
2805	Gasoline Reciprocating Engines, except Aircraft	SA/MMP	DC/ATAC	SA
2810	Gasoline Reciprocating Engines, Aircraft	SA/MMP		

2815	Diesel Engines and Components	SA/MMP	DC/DCSC	SA
2820	Steam Engines, Reciprocating and Components	SA/MMP		
2825	Steam Turbines and Components	WR/MMI		WR
2830	Water Turbines and Water Wheels & Components	SA/MMP		
2835	Gas Turbines and Jet Engines, except Aircraft	SA/MMP		SA
2840	Gas Turbines & Jet Engines, Aircraft & Comp	SA/MMP		
2845	Rocket Engines and Components	SA/MMP		
2850	Gasoline Rotary Engines	SA	DC	
2895	Miscellaneous Engines and Components	WR/MMI	DC	WR
2910	Engine Fuel Systems Components, Nonaircraft	SA/MMP	DC/ATAC	SA
2915	Engine Fuel System, Components, Aircraft	SA/MMP		SA
2920	Engine Electrical System Components, Nonaircraft	SA/MMP	DC/ATAC	SA
2925	Engine Electrical System Components, Aircraft	SA/MMP		SA
2930	Engine Cooling System Components, Nonaircraft	SA/MMP	DC/ATAC	SA
2935	Engine Cooling System Components, Aircraft	OC/MMI		OC
2940	Engine Air and Oil Filters, Strainers, Nonaircraft	SA/MMP	DC/ATAC	SA
2945	Engine Air and Oil Filters, Strainers, Aircraft	OC/MMI		OC
2950	Turbosuperchargers	OC/MMI		OC
2990	Miscellaneous Engine Accessories, Nonaircraft	SA/MMP	DC/ATAC	SA
2995	Miscellaneous Engine Accessories, Aircraft	OC/MMI		OC
3010	Torque Converters and Speed Changers	SA/MMI	DC	SA
3020	Gears, Pulleys, Sprockets and Transmission Chain	SA/MMI	DC	SA
3030	Belting, Drive Belts, Fan Belts, & Accessories	SA/MMI	DC	SA
3040	Miscellaneous Power Transmission Equipment	SA/MMI	DC	SA
3110	Bearings, Antifriction, Unmounted	WR/MMI	DI	WR
3120	Bearings, Plain, Unmounted	WR/MMI	DI	WR
3130	Bearings, Mounted	WR/MMI	DI	WR
3210	Sawmill and Planing Mill Machinery	WR/MMI	DG	WR
3220	Woodworking Machines	WR/MMI	DG	WR
3230	Tools and Attachments for Woodworking Machinery	WR/MMI	DG	WR
3405	Saws and Filing Machines	WR/MMI	DG	
3408	Machining Centers and Way Type Machines	WR/MMI	DG	
3410	Electrical and Ultrasonic Erosion Machines	WR/MMI	DG	
3411	Boring Machines	WR/MMI	DG	
3412	Broaching Machines	WR/MMI	DG	
3413	Drilling Machines	WR/MMI	DG	
3414	Gear Cutting and Finishing Machines	WR/MMI	DG	
3415	Grinding Machines	WR/MMI	DG	
3416	Lathes	WR/MMI	DG	
3417	Milling Machines	WR/MMI	DG	
3418	Planers	WR/MMI	DG	
3419	Miscellaneous Machine Tools	WR/MMI	DG	
3422	Rolling Mills and Drawing Machines	WR/MMI		
3424	Metal Heat Treating Equipment	WR/MMI	DG	
3426	Metal Finishing Equipment	WR/MMI	DG	
3431	Electric Arc Welding Equipment	WR/MMI	DG	
3432	Electric Resistance Welding	WR/MMI	DG	
3433	Gas Welding, Heat Cutting, and Metalizing Equip	WR/MMI	DG	
3436	Welding Positioners and Manipulators	WR/MMI	DG	
3438	Miscellaneous Welding Equipment	WR/MMI	DG	WR
3439	Miscellaneous Welding, Soldering, and Brazing	WR/MMI	DG	

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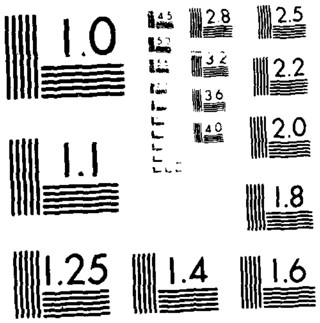

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

3441	Bending and Forming Machines	WR/MMI	DG	
3442	Hydraulic Pneumatic Presses, Power Driven	WR/MMI	DG	
3443	Mechanical Presses, Power Driven	WR/MMI	DG	
3444	Manual Presses	WR/MMI	DG	
3445	Punching and Shearing Machines	WR/MMI	DG	
3446	Forging Machinery and Hammers	WR/MMI	DG	
3447	Wire and Metal Ribbon Forming Machines	WR/MMI	DG	
3448	Riveting Machines	WR/MMI	DG	
3449	Miscellaneous Secondary Metal Forming & Cutting Machinery	WR/MMI	DG	
3450	Machine Tools, Portable	WR/MMI	DG	
3455	Cutting Tools for Machine Tools	WR/MMI	DG	WR
3456	Cutting and Forming Tools for Secondary	WR/MMI	DG	WR
3460	Machine Tool Accessories	WR/MMI	DG	WR
3461	Accessories for Secondary Metalworking Machinery	WR/MMI	DG	WR
3465	Production Jigs, Fixtures and Templates	WR/MMI	DG	WR
3470	Machine Shop Sets, Kits, and Outfits	WR/MMI	DG	WR
3510	Laundry and Dry Cleaning Equipment	AFESC	DG	
3520	Shoe Repairing Equipment	WR/MMI	DG	WR
3530	Industrial Sewing Machines and Mobile Textile Repair	WR/MMI	DG	WR
3540	Wrapping and Packaging Machinery	WR/MMI	GSA	WR
3550	Vending and Coin Operating Machines	WR/MMI		
3590	Miscellaneous Service and Trade Equipment	WR/MMI	GSA	WR
3605	Food Products Machinery and Equipment	WR/MMI	DG	WR
3610	Printing, Duplicating and Bookbinding Equipment	WR/MMI	DG	WR
3611	Industrial Marking Machines	WR/MMI	DG	
3615	Pulp and Paper Industries Machinery	WR/MMI	DG	WR
3620	Repair and Plastics Working Machinery	WR/MMI	DG	
3625	Textile Industries Machinery	WR/MMI	DG	WR
3630	Clay and Concrete Products Industries Machinery	WR/MMI	DG	WR
3635	Glass Industries Machinery	WR/MMI	DG	
3640	Tobacco Manufacturing Machinery	WR/MMI	DG	WR
3645	Leather Tanning and Leather Working Industries	WR/MMI		WR
3650	Chemical & Pharmaceutical Products Manufacturing	WR/MMI		
3655	Gas Generating & Dispensing Systems, Fixed/Mobile	SA/MMI	DG	SA
3660	Industrial Size Reduction Machinery	WR/MMI	DG	
3670	Specialized Semi-Conductor Microelectronic Circuit	SM/MMI		SM
3680	Foundry Machinery, Related Equipment and Supplies	WR/MMI	DG	
3685	Specialized Metal Container Manufacturing Machinery	WR/MMI	DG	
3690	Specialized Ammunition and Ordnance Machinery	OO/MMI		
3693	Industrial Assembly Machine	WR/MMI	DG	
3694	Clean Work Stations, Controlled Environment/Rel Eq	WR/MMI	DG	
3695	Miscellaneous Special Industry Machinery	WR/MMI	DG	
3710	Soil Preparation Equipment	WR/MMI	DC	WR
3720	Harvesting Equipment	WR/MMI	DC	WR
3730	Dairy, Poultry and Livestock Equipment	WR/MMI	DC	
3740	Pest, Disease, and Frost Control Equipment	WR/MMI	DC	WR
3750	Gardening Implements and Tools	WR/MMI	GSA	WR
3760	Animal Drawn Vehicles and Farm Trailer	WR/MMI	DC	
3770	Saddlery, Harness, Whips, & Related Animal Furnish	WR/MMI	DC	WR

3805	Earth Moving and Excavating Equipment	WR/MMI	DC	WR
3810	Cranes and Crane--Shovels	WR/MMI	DC	WR
3815	Cranes and Crane--Shovel Attachments	WR/MMI	DC	WR
3820	Mining, Rock Drilling, Earth Boring, & Related Eq	WR/MMI	DC	WR
3825	Road Clearing and Cleaning Equipment	WR/MMI	DC	WR
3830	Truck and Tractor Attachments	WR/MMI	DC	WR
3835	Petroleum Production and Distribution Equipment	WR/MMI	DC	WR
3895	Miscellaneous Construction Equipment	WR/MMI	DC	WR
3910	Conveyors	WR/MMI	DC	WR
3915	Materiel Feeders	WR/MMI	DC	WR
3920	Materiel Handling Equipment, nonself-propelled	WR/MMI	DG	WR
3930	Warehouse Trucks and Tractors, self-propelled	WR/MMI	DC	WR
3940	Blocks, Tackle, Rigging, and Slings	WR/MMI	DI	WR
3950	Winches, Hoists, Cranes, and Derricks	WR/MMI	DC	WR
3960	Elevators and Escalators	WR/MMI		WR
3990	Miscellaneous Materiel Handling Equipment	WR/MMI	DG	WR
4010	Chain and Wire Rope	SA/MMI	DI	SA
4020	Fiber Rope, Cordage, and Twine	SA/MMI	DI	SA
4030	Fittings for Rope, Cable, and Chain	SA/MMI	DI	SA
4110	Self-Contained Refrigeration Equipment	SA/MMI	DG	SA
4120	Self-Contained Air-Conditioning and Accessories	SA/MMI	DG	SA
4130	Refrigeration and Air-Conditioning Components	SA/MMI	DG	SA
4140	Fans and Air Circulators Nonindustrial	SA/MMI	DG	SA
4210	Fire Fighting Equipment	WR/MMI	DC	WR
4220	Marine, Life Saving and Diving Equipment	WR/MMI	DC	WR
4230	Decontaminating and Impregnating Equipment	WR/MMI	DG	WR
4240	Safety and Rescue Equipment	WR/MMI	DG	WR
4310	Compressors and Vacuum Pumps	WR/MMI	DC	WR
4320	Power and Hand Pumps	WR/MMI	DC	WR
4330	Centrifuglas, Separators, & Pressure & Vacuum Fixtures	WR/MMI	DC	WR
4410	Industrial Boilers	WR/MMI		WR
4420	Heat Exchangers and Steam Condensers	WR/MMI		WR
4430	Industrial Furnaces, Kilns, and Ovens	WR/MMI	DC	WR
4440	Driers, Dehydrators, and Anhydrators	WR/MMI	DC	WR
4460	Air Purification Equipment	WR/MMI	DC	WR
4470	Nuclear Reactors	SA/MMI		SA
4510	Plumbing Fixtures and Accessories	WR/MMI	DC	WR
4520	Space Heating Equipment and Domestic Water Heaters	WR/MMI	DC	WR
4530	Fuel Burning Equipment Units	WR/MMI	DC	WR
4540	Miscellaneous Plumbing, Heating, & Sanitation Equip	WR/MMI	DC	WR
4610	Water Purification Equipment	WR/MMI	DC	WR
4620	Water Distillation Equipment, Marine & Industrial	WR/MMI	DC	WR
4630	Sewage Treatment Equipment	WR/MMI	DC	WR
4710	Pipe and Tube, Metal	SA/MMI	DC	SA
4720	Hose and Tubing, Flexible	SA/MMI	DC	SA
4730	Fittings and Specialties: Hose, Pipe, and Tube	SA/MMI	DC	SA
4810	Valves, Powered	SA/MMI	DC	SA
4820	Valves, Nonpowered	SA/MMI	DC	SA
4910	Motor Vehicle Maintenance & Repair Shop Spec Equip	SA/MMI		SA
4920	Aircraft Maintenance & Repair Shop Specialized Eq	SA/MMI		SA

4921	Torpedo Maintenance, Repair & Checkout Spec Eq	OO/MMW		
4923	Depth Charges & Underwater Mines Maintenance	OO/MMW		
4925	Ammunition Maintenance & Repair Shop Spec Equip	OO/MMW		OO
4927	Rocket Maintenance, Repair, & Checkout Spec Equip	OO/MMW		
4930	Lubrication and Fuel Dispensing Equipment	SA/MMI	DC	SA
4931	Fire Control Maintenance and Repair Shop Spec Equip	WR/MMI		WR
4933	Weapons Maintenance and Repair Shop Spec Equip	WR/MMI		WR
4935	Guided Missile Maintenance, Repair & Checkout	OO/MMI		
4940	Miscellaneous Maintenance & Repair Shop Spec Equip	SA/MMI		SA
4960	Space Vehicle Maintenance, Repair & Checkout	SM/MMI		SM
5110	Hand Tools, Edged, Nonpowered	WR/MMI	GSA	WR
5120	Hand Tools, Nonedged, Nonpowered	WR/MMI	GSA	WR
5130	Hand Tools, Power Driven	WR/MMI	GSA	WR
5133	Drill Bits, Counterbores, & Countersinks, Hand/Mach	WR/MMI	GSA	WR
5136	Taps, Dies, and Collets, Hand and Machine	WR/MMI	GSA	WR
5140	Tool and Hardware Boxes	WR/MMI	GSA	WR
5180	Sets, Kits and Outfits of Hand Tools	WR/MMI	GSA	WR
5210	Measuring Tools, Craftsmen's	WR/MMI	GSA	WR
5220	Inspection Gages and Precision Layout Tools	WR/MMI		WR
5280	Sets, Kits and Outfits of Measuring Tools	WR/MMI		WR
5305	Screws	SA/MMI	DI	SA
5306	Bolts	SA/MMI	DI	SA
5307	Studs	SA/MMI	DI	SA
5310	Nuts and Washers	SA/MMI	DI	SA
5315	Nails, Keys and Pins	SA/MMI	DI	SA
5320	Rivets	SA/MMI	DI	SA
5325	Fastening Devices	SA/MMI	DI	SA
5330	Packing and Gasket Materiel	SA/MMI	DI	SA
5335	Metal Screening	SA/MMI	DI	SA
5340	Miscellaneous Hardware	SA/MMI	DI	SA
5345	Disks and Stones, Abrasive	WR/MMI	GSA	WR
5350	Abrasive Materiel	WR/MMI	GSA	WR
5355	Knobs and Pointers	SA/MMI	DI	SA
5360	Coil Flat and Wire Springs	SA/MMI	DI	SA
5365	Rings, Shims, and Spacers	SA/MMI	DI	SA
5410	Prefabricated and Portable Buildings	WR/MMI	DC	WR
5420	Bridges, Fixed and Floating	WR/MMI	DC	WR
5430	Storage Tanks	SA/MMI	DC	SA
5440	Scaffolding Equipment and Concrete Forms	WR/MMI	DC	WR
5445	Prefabricated Tower Structures	WR/MMI		WR
5450	Miscellaneous Prefabricated Structures	WR/MMI	DC	WR
5510	Lumber and Related Basic Wood Materiel	WR/MMI	DC	
5520	Millwork	WR/MMI	DC	
5530	Plywood and Veneer	WR/MMI	DC	
5610	Mineral Construction Materiel, Bulk	WR/MMI	GSA	WR
5620	Building Glass, Tile, Brick, and Block	WR/MMI	GSA	WR
5630	Pipe and Conduit, Nonmetallic	WR/MMI	GSA	WR
5640	Wallboard, Building Paper and Thermal Instal Mat	WR/MMI	GSA	WR
5650	Roofing and Siding Materiel	WR/MMI	GSA	WR
5660	Fencing, Fences and Gates	WR/MMI	DC	WR
5670	Architectural and Related Metal Products	WR/MMI	GSA	WR

5680 Miscellaneous Construction Materiel	WR/MMI	GSA	WR
5805 Telephone and Telegraph Equipment	SM/MMC	DE	SM
5810 Communications Security Equipment and Components	AFCD		FX 7030
5811 Other Cryptologic Equipment and Components	AFCD		FX 7030
5815 Teletype and Facsimile Equipment	SM/MMC	DE	SM
5820 Radio & Television Communication Equipment/NoAirbor	SM/MMC	DE	SM
5821 Radio and Television Communication Equipment/Airbor	WR/MMI	DE	WR
5825 Radio Navigation Equipment, except Airborne	SM/MMC	DE	SM
5826 Radio Navigation Equipment, Airborne	WR/MMI		WR
5830 Intercommunications and Public Address Sys/NoAirbor	SM/MMC	DE	SM
5831 Intercommunications and Public Address Sys/Airborne	WR/MMI	DE	WR
5835 Sound Recording and Reproducing Equipment	SM/MMC	DE	SM
5840 Radar Equipment, except Airborne	SM/MMC		SM
5841 Radar Equipment, Airborne	WR/MMI		WR
5845 Underwater Sound Equipment	SM/MMC		SM
5850 Visible and Invisible Light Communication Equipment	SM/MMC		SM
5855 Night Vision Equipment	WR/MMI		WR
5860 Stimulated Coherent Radiation Devices, Comp&Access	SM/MMC		SM
5865 Electronic Countermeasure Equipment	WR/MMI		
5895 Miscellaneous Communications Equipment, Airborne	WR/MMI	DE	WR
5905 Resistors	SM/MMI	DE	SM
5910 Capacitors	SM/MMI	DE	SM
5915 Filters and Networks	SM/MMI	DE	SM
5920 Fuses and Lighting Arrestors	SM/MMI	DE	SM
5925 Circuit Breakers	SM/MMI	DE	SM
5930 Switches	SM/MMI	DE	SM
5935 Connectors, Electrical	SM/MMI	DE	SM
5940 Lugs, Terminals, and Terminal Strips	SM/MMI	DG	SM
5945 Relays, Contactors, and Solenoids	SM/MMI	DE	SM
5950 Coils and Transformers	SM/MMI	DE	SM
5955 Piezoelectric Crystals	WR/MMI	DE	WR
5960 Electron Tubes and Associated Hardware	SM/MMI	DE	SM
5961 Semiconductors Devices and Associated Hardware	SM/MMI	DE	SM
5962 Microelectronic Circuit Devices	SM/MMI	DE	SM
5965 Headsets, Handsets, Microphones, and Speakers	SM/MMI	DE	SM
5970 Electrical Insulators and Insulating Materiel	SM/MMI	DG	SM
5975 Electrical Hardware and Supplies	SM/MMI	DG	SM
5977 Electrical Contact Brushes and Electrodes	SM/MMI	DG	SM
5985 Antennas, Waveguides, and Related Equipment	SM/MMI	DE	SM
5990 Synchros and Resolvers	SM/MMI	DE	SM
5995 Cable, Cord, & Wire Assemblies, Communications Eq	SM/MMI	DG	SM
5999 Miscellaneous Electrical and Electrical Components	SM/MMI	DE	SM
6105 Motors, Electrical	SM/MMI	DG	SM
6110 Electrical Control Equipment	SM/MMI	DG	SM
6115 Generators and Generator Sets, Electrical	SM/MMI	DG	SM
6116 Fuel Cell Power Units, Components and Accessories	SM/MMI		SM
6120 Transformers: Distribution and Power Station	SM/MMI	DG	SM
6125 Converters, Electrical, Rotating	SM/MMI	DG	SM
6130 Rectifying Equipment, Electrical	SM/MMI	DG	SM
6135 Batteries, Primary	SM/MMI		SM
6140 Batteries, Secondary	SM/MMI	DG	SM

6145	Wire and Cable, Electrical	SM/MMI	DI	SM
6150	Miscellaneous Electrical Powr & Distribution Equip	SM/MMI	DG	SM
6210	Indoor and Outdoor Electric Lighting Fistures	SA/MMI	DG	SA
6220	Electric Vehicular Lights and Fixtures	SA/MMI	DG	
6230	Electric Portable and Hand Lighting Equipment	SA/MMI	DG	SA
6240	Electric Lamps	SA/MMI	DG	SA
6250	Ballasts Lamp-holders and Starters	SA/MMI	DG	SA
6260	Nonelectrical Lighting Fixtures	SA/MMI	DG	SA
6310	Traffic and Transit Signal Systems	SA/MMI	DG	SA
6320	Shipboard Alarm and Signal Systems	SA/MMI	DG	SA
6330	Railroad Signal and Warning Devices	WR/MMI	DG	
6340	Aircraft Alarm and Signal Systems	SA/MMI		SA
6350	Miscellaneous Alarm and Signal Systems	SA/MMI	DG	SA
6505	Drugs, Biologicals and Official Reagents	AFMMFO	DP	
6508	Medicated Cosmetics and Toiletries	AFMMFO	DP	
6510	Surgical Dressing Materiels	AFMMFO	DP	
6515	Medical and Surgical Instruments Equip & Supplies	AFMMFO	DP	
6520	Dental Instruments, Equipment and Supplies	AFMMFO	DP	
6525	X-Ray Equipment and Supplies: Medical/Dental/Vet	AFMMFO	DP	
6530	Hospital Furniture, Equipment, Utensils & Supplies	AFMMFO	DP	
6532	Hospital and Surgical Clothing, Rel Spec Purp Items	AFMMFO	DP	
6540	Opticism Instruments, Equipment and Supplies	AFMMFO	DP	
6545	Medical Sets, Kits and Outfits	AFMMFO	DP	
6605	Navigational Instruments	OC/MMI		OC
6610	Flight Instruments	OC/MMI		OC
6615	Automatic Pilot Mechanisms & Airborne Gyro Comp	OC/MMI		OC
6620	Engine Instruments	OC/MMI		OC
6625	Electrical & Electronic Properties Measuring, Test Instruments	SA/MMI	DE	SA
6630	Chemical Analysis Instruments	SA/MMI	DE	SA
6635	Physical Properties Testing Equipment	SA/MMI	DG	SA
6636	Environmental Chambers and Related Equipment	SA/MMI		SA
6640	Laboratory Equipment and Supplies	SA/MMI	DP	SA
6645	Time Measuring Instruments	SA/MMI	DG	SA
6650	Optical Instruments	SA/MMI		SA
6655	Geophysical and Astronomical Instruments	SA/MMI	DG	SA
6660	Meteorological Instruments and Apparatus	SM/MMC	DG	SM
6665	Hazard-Detecting Instruments and Apparatus	SA/MMI		SA
6670	Scales and Balances	SA/MMI	DG	SA
6675	Drafting, Surveying, and Mapping Instruments	SA/MMI	DG	SA
6680	Liquid & Gas Flow, Liquid Level, & Mechanical Motion	SA/MMI	DG	SA
6685	Pressure, Temperature, & Humidity Measures/Control	SA/MMI	DG	SA
6695	Combination and Miscellaneous Instruments	SA/MMI	DG	SA
6710	Cameras, Motion Picture	OO/MMI	DG	OO
6720	Cameras, Still Picture	OO/MMI	DG	OO
6730	Photographic Projection Equipment	OO/MMI	DG	OO
6740	Photographic Developing and Finishing Equipment	OO/MMI	DG	OO
6750	Photographic Supplies	OO/MMI	DG	OO
6760	Photographic Equipment and Accessories	OO/MMI	DG	OO
6770	Film, Processed	OO/MMI	DG	OO

6780	Photographic Sets, Kits and Outfits	OO/MMI		OO
6810	Chemicals	SA	DG	SA
6820	Dyes	SA	DG	SA
6830	Gases: Compressed and Liquefied	SA	DG	SA
6840	Pest Control Agents and Disinfectants	SA	DG	SA
6850	Miscellaneous Chemical Specialties	SA	DG	SA
6910	Training Aids	OO/MMI		OO
6920	Armament Training Devices	OO/MMI		OO
6930	Operational Training Devices	OO/MMI		OO
6940	Communication Training Devices	OO/MMI		OO
7010	Automatic Data Processing Equipment Configuration	WR/MMI		WR
7020	Automatic Data Processing Central Units	WR/MMI		WR
7021	Automatic Data Processing Central Unit (Computer)	WR/MMI		WR
7022	Automatic Data Processing Central Unit (Hybrid)	WR/MMI		WR
7025	Automatic Data Processing Input/Output & Storage Device	WR/MMI		WR
7030	Automatic Data Processing Software	WR/MMI		WR
7035	Automatic Data Processing Accessorial Equipment	WR/MMI		WR
7040	Punched Card Equipment	WR/MMI		WR
7045	Automatic Data Processing Supplies & Support Equip	WR/MMI		WR
7050	Automatic Data Processing Components	WR/MMI		WR
7105	Household Furniture	WR/MMI	GSA	WR
7110	Office Furniture	WR/MMI	GSA	WR
7125	Cabinets, Lockers, Bins, and Shelving	WR/MMI	GSA	WR
7195	Miscellaneous Furniture and Fixtures	WR/MMI	GSA	WR
7210	Household Furnishings	AFC&TO	DP	
7220	Floor Coverings	WR/MMI	GSA	WR
7230	Draperies, Awnings, and Shades	WR/MMI	GSA	WR
7240	Household and Commercial Utility Containers	WR/MMI	GSA	WR
7290	Miscellaneous Household & Commercial Furnishings & Appliances	WR/MMI	GSA	WR
7310	Food Cooking, Baking, and Servicing Equipment	WR/MMI	DG	WR
7320	Kitchen Equipment and Appliances	WR/MMI	DG	WR
7330	Kitchen Hand Tools and Utensils	WR/MMI	GSA	WR
7340	Cutlery and Flatware	WR/MMI	GSA	WR
7350	Tableware	WR/MMI	GSA	WR
7360	Sets, Kits, and Outfits, Food Preparation & Serving	WR/MMI	DG	WR
7420	Accounting and Calculating Machines	WR/MMI	GSA	WR
7430	Typewriters and Office Type Composing Machines	WR/MMI	GSA	WR
7450	Office Type Sound Recording and Reproducing Machine	WR/MMI		WR
7460	Visible Record Equipment	WR/MMI	GSA	WR
7490	Miscellaneous Office Machines	WR/MMI	GSA	WR
7510	Office Supplies	WR/MMI	GSA	WR
7520	Office Devices and Accessories	WR/MMI	GSA	WR
7530	Stationery and Record Forms	WR/MMI	GSA	WR
7540	Standard Forms	WR/MMI	GSA	
7610	Books and Pamphlets	WR/MMI	DG	WR
7630	Newspapers and Periodicals	WR/MMI	DG	
7640	Maps, Atlases, Charts and Globes	WR/MMI	DG	
7650	Drawings and Specifications	AFALD/	DG	WP
7660	Sheet and Book Music	WR/MMI		

7670	Microfilm, Processed	AFALD/	DG	WP
7690	Miscellaneous Printed Matter	WR/MMI	DG	
7710	Musical Instruments	WR/MMI	GSA	WR
7720	Musical Instruments Parts and Accessories	WR/MMI	GSA	WR
7730	Phonographs, Radio and Television Sets, Home-type	WR/MMI	GSA	WR
7740	Phonograph Records	WR/MMI	GSA	WR
7810	Athletic and Sporting Equipment	WR/MMI	GSA	WR
7820	Games, Toys, and Wheeled Goods	WR/MMI	GSA	WR
7830	Recreational and Gymnastic Equipment	WR/MMI	GSA	WR
7910	Floor Polishers and Vacuum Cleaners	WR/MMI	GSA	WR
7920	Brooms, Brushes, Mops, and Sponges	WR/MMI	GSA	WR
7930	Cleaning and Polishing Compounds and Preparations	WR/MMI	GSA	WR
8010	Paints, Dopes, Varnishes, and Related Products	WR/MMI	GSA	WR
8020	Paint and Artists' Brushes	WR/MMI	GSA	WR
8030	Preservative and Sealing Compounds	WR/MMI	GSA	WR
8040	Adhesives	WR/MMI	GSA	WR
8105	Bags and Sacks	WR/MMI	GSA	WR
8110	Drums and Cans	SA/MMI	DC	SA
8115	Boxes, Cartons, and Crates	WR/MMI	GSA	WR
8120	Gas Cylinders	SA/MMI	DG	SA
8125	Bottles and Jars	WR/MMI	DG	WR
8130	Reels and Spools	WR/MMI	DG	WR
8135	Packaging and Packing Bulk Materiel	WR/MMI	GSA	WR
8140	Ammunition Boxes, Packages, and Special Container	OO/MMW		OO
8145	Specialized Shipping and Storage Containers	WR/MMI		WR
8305	Textile Fabrics	AFC&TO	DP	
8310	Yarn and Threads	AFC&TO	DP	
8315	Notions, and Apparel Findings	AFC&TO	DP	
8320	Padding and Stuffing Materiel	AFC&TO	DP	
8325	Fur Materiel	AFC&TO	DP	
8330	Leather	AFC&TO	DP	
8335	Shoe Findings and Soling Materiel	AFC&TO	DP	
8340	Tents and Tarpaulins	AFC&TO	DP	
8345	Flags and Pennants	AFC&TO	DP	
8405	Outerwear, Men's	AFC&TO	DP	
8410	Outerwear, Women's	AFC&TO	DP	
8415	Clothing, Special Purpose	AFC&TO	DP	
8420	Underwear and Nightwear, Men's	AFC&TO	DP	
8425	Underwear and Nightwear, Women's	AFC&TO	DP	
8430	Footwear, Men's	AFC&TO	DP	
8435	Footwear, Women's	AFC&TO	DP	
8440	Hosiery, Handwear, and Clothing Accessories, Men's	AFC&TO	DP	
8445	Hosiery, Handwear, and Clothing Accessories, Women's	AFC&TO	DP	
8450	Children's and Infants' Apparel and Accessories	AFC&TO	DP	
8455	Badges and Insignia	AFC&TO	DP	
8460	Luggage	AFC&TO	DP	
8465	Individual Equipment	AFC&TO	DP	
8470	Armor Personal	AFC&TO	DP	
8475	Specialized Flight Clothing, and Accessories	SA/MMI		SA
8510	Perfumes, Toilet Preparations, and Powders	WR/MMI	GSA	
8520	Toilet Soap, Shaving Preparations, & Dentifrices	WR/MMI	GSA	

8530 Personal Toiletry Articles	WR/MMI	GSA	
8540 Toiletry Paper Products	WR/MMI	GSA	
8710 Forage and Feed	WR/MMI	GSA	
8720 Fertilizers	WR/MMI	GSA	
8730 Seeds and Nursery Stock	WR/MMI	GSA	
8810 Live Animals, Raised for Food	SA/MMI	DP	
8820 Live Animals, Not Raised for Food	SA/MMI	DP	
8905 Meat, Poultry and Fish	AFESC	DP	
8910 Dairy Foods and Eggs	AFESC	DP	
8915 Fruits and Vegetables	AFESC	DP	
8920 Bakery and Cereal Products	AFESC	DP	
8925 Sugar, Confectionery and Nuts	AFESC	DP	
8930 Jams, Jellies and Preserves	AFESC	DP	
8935 Soups and Bouillon	AFESC	DP	
8940 Special Dietary Foods & Food Specialty Preparations	AFESC	DP	
8945 Food Oils and Fats	AFESC	DP	
8950 Condiments and Related Products	AFESC	DP	
8955 Coffee, Tea, and Cocoa	AFESC	DP	
8960 Beverages, Nonalcoholic	AFESC	DP	
8965 Beverages, Alcoholic		DP	
8970 Composite Food Packages	AFESC	DP	
8975 Tobacco Products	AFESC	DP	
9110 Fuels, Solid	SA	DG	SA
9130 Liquid Propellants and Fuels, Petroleum Base	SA	DF	SA
9135 Liquid Propellants Fuels & Oxidizers, Chemical Base	SA		SA
9140 Fuel Oils	SA	DF	SA
9150 Oils and Greases, Cutting, Lubricating, & Hydraulic	SA	DG	SA
9160 Miscellaneous Waxes, Oils, and Fats	SA	DG	SA
9310 Paper and Paperboard	WR/MMI	GSA	WR
9320 Rubber Fabricated Materiel	SA/MMI	DG	SA
9330 Plastics Fabricated Materiel	WR/MMI	DG	WR
9340 Glass Fabricated Materiel	WR/MMI	DG	WR
9350 Refractories and Fire Surfacing Materiel	WR/MMI	DG	WR
9390 Miscellaneous Fabricated Nonmetallic Materiel	WR/MMI	DG	WR
9410 Crude Grades of Plant Materiels	WR/MMI	DP	
9420 Fibers: Vegetable, Animal, and Synthetic	AFC&TO	DP	WR
9430 Miscellaneous Crude Animal Products & Inedible	AFC&TO	DP	
9440 Miscellaneous Crude Agricultural & Forestry Prods	WR/MMI	DG	
9450 Nonmetallic Scrap, Except Textile	WR/MMI	DG	
9505 Wire, Nonelectrical, Iron and Steel	WR/MMI	DI	WR
9510 Bars and Rods, Iron and Steel	WR/MMI	DI	WR
9515 Plate, Sheet, and Strip, Iron and Steel	WR/MMI	DI	WR
9520 Structural Shapes, Iron and Steel	WR/MMI	DI	WR
9525 Wire, Nonelectrical, Nonferrous Base Metal	WR/MMI	DI	WR
9530 Bars and Rods, Nonferrous Base Metal	WR/MMI	DI	WR
9535 Plate, Sheet, Strip, & Foil, Nonferrous Base Metal	WR/MMI	DI	WR
9540 Structural Shapes, Nonferrous Base Metal	WR/MMI	DI	WR
9545 Plate, Sheet, Strip, Foil, & Wire, Precious Metal	WR/MMI	DI	WR
9610 Ores	WR/MMI	DI	
9620 Mineral, Natural and Synthetic	WR/MMI	DI	WR
9630 Additive Metal Material and Master Alloys	WR/MMI	DI	WR

9640 Iron and Steel Primary and Semi-finished Products	WR/MMI	DI	WR
9650 Nonferrous Base Metal Refinery & Intermediate Forms	WR/MMI	DI	WR
9660 Precious Metals Primary Forms	WR/MMI	DI	
9670 Irons and Steel Scrap	WR/MMI	DI	
9680 Nonferrous Metal Scrap	WR/MMI	DI	
9905 Signs, Advertising Displays, & Identification Plate	WR/MMI	GSA	WR
9910 Jewelry	WR/MMI		
9915 Collectors Items	WR/MMI		
9920 Smokers' Articles and Matches	WR/MMI	GSA	WR
9925 Ecclesiastical Equipment, Furnishings, and Supplies	AFLC	DG	
9930 Memorials: Cemeterial & Mortuary Equipment & "	AFLC	DG	

Appendix D

SUPPORTING REGRESSION TABLES

Table D.1

REGRESSION OF C-5 FSCSUM ON AGE AND FH12

Source	SS	df	MS
Model	9.7476E+10	2	4.8738E+10
Residual	2.6666E+10	7	3.8094E+09
Total	1.2414E+11	9	1.3794E+10

Number of obs	=	9
F(2, 7)	=	12.79
Prob > F	=	0.0046
R-square	=	0.7852
Adj R-square	=	0.7238
Root MSE	=	61721.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					100264.2
age	1102563.	670476.3	1.644	0.144	.0964699
fh12	-.0552804	.6241353	-0.089	0.932	106585.9

Plot of Residuals of fscsum

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          |
-66065.7 +                         *
          +-----------------------------------------------------------------+
            1976.                      year                          1984.
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Table D.2

REGRESSION OF C-5 FSC3 ON AGE AND FH12

Source	SS	df	MS
Model	929231077.	2	464615539.
Residual	730702750.	7	104386107.
Total	1.6599E+09	9	184437092.

Number of obs	=	9
F(2, 7)	=	4.45
Prob > F	=	0.0566
R-square	=	0.5598
Adj R-square	=	0.4340
Root MSE	=	10217.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc3					10018.11
age	38547.66	110987.8	0.347	0.739	.0964699
fh12	.0603106	.1033167	0.584	0.578	106585.9

Plot of Residuals of fsc3

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          +----------------------------------------------------------------+
            1976.                      year                         1984.
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Table D.3

REGRESSION OF C-5 FSC4 ON AGE AND FH12

Source	SS	df	MS
Model	949405382.	2	474702691.
Residual	321001524.	7	45857360.6
Total	1.2704E+09	9	141156323.

Number of obs	=	9	
F(2,	7)	=	10.35
Prob > F		=	0.0081
R-square		=	0.7473
Adj R-square		=	0.6751
Root MSE		=	6771.8

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc4					10306.67
age	5138.534	73562.83	0.070	0.946	.0964699
fh12	.0915557	.0684784	1.337	0.223	106585.9

Plot of Residuals fsc4

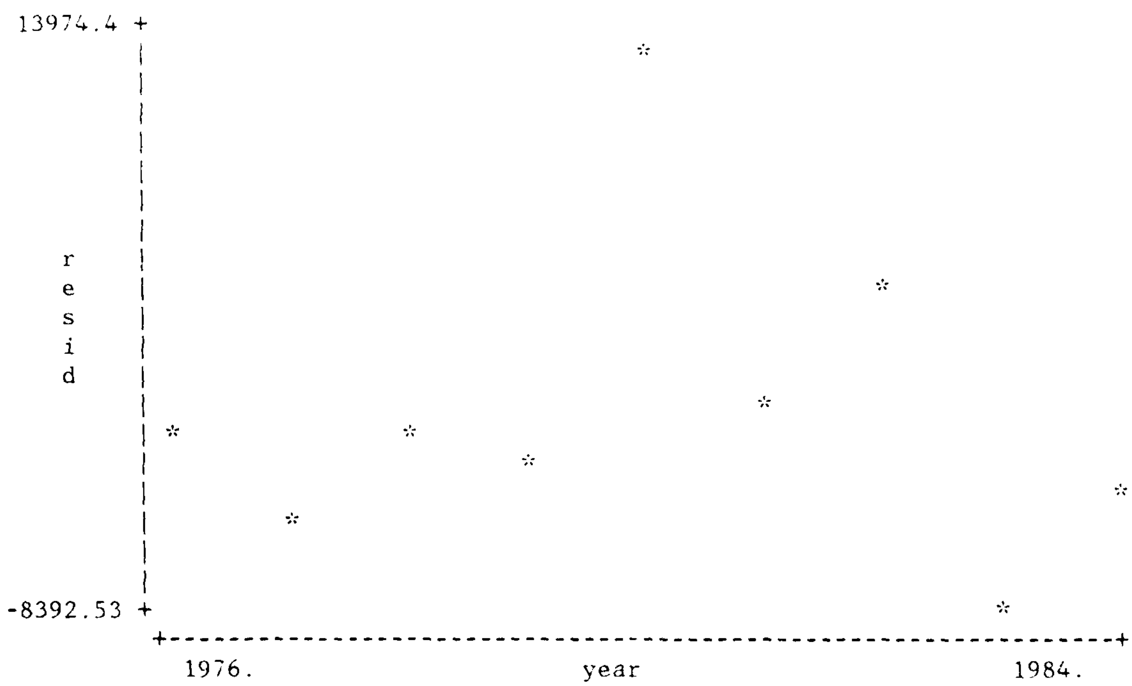

Table D.4

REGRESSION OF C-5 FSC5 ON AGE AND FH12

Source	SS	df	MS
Model	551375710.	2	275687855.
Residual	453996841.	7	64856691.6
Total	1.0054E+09	9	111708061.

Number of obs	=	9
F(2, 7)	=	4.25
Prob > F	=	0.0619
R-square	=	0.5484
Adj R-square	=	0.4194
Root MSE	=	8053.4

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc5					7665.444
age	74464.71	87484.54	0.851	0.423	.0964699
fh12	.0041205	.0814379	0.051	0.961	106585.9

Plot of Residuals fsc5

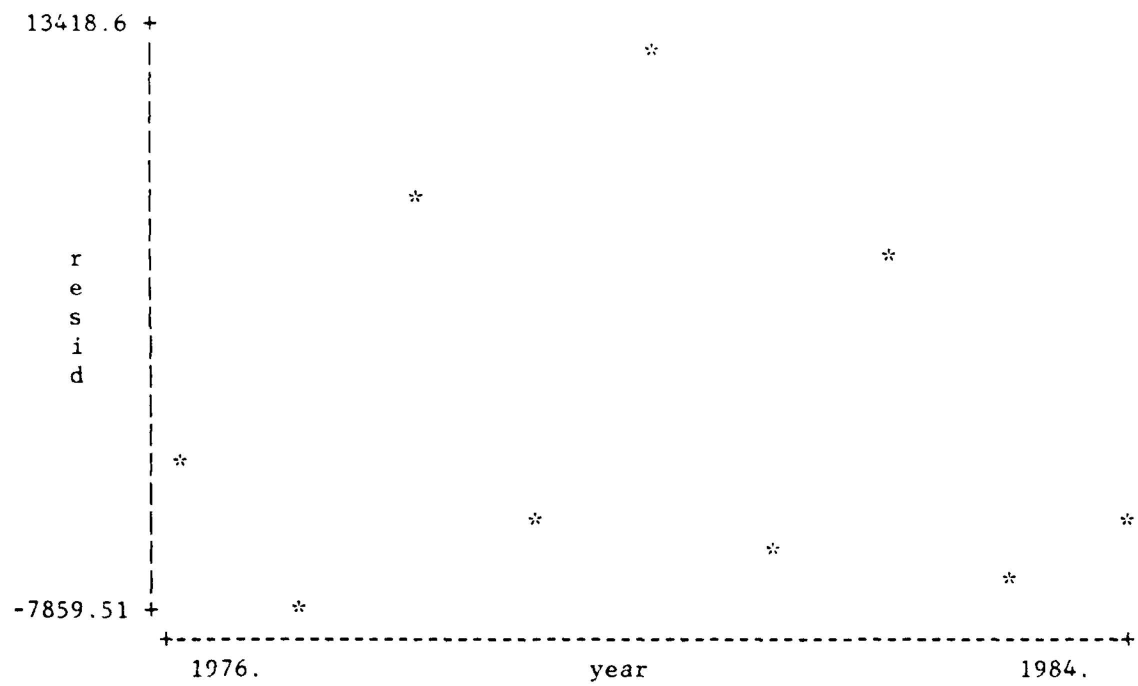

Table D.5

REGRESSION OF C-5 FSC6 ON AGE AND FH12

Source	SS	df	MS
Model	86007814.7	2	43003907.4
Residual	15555295.3	7	2222185.04
Total	101563110.	9	11284790.0

Number of obs	= 9
F(2, 7)	= 19.35
Prob > F	= 0.0014
R-square	= 0.8468
Adj R-square	= 0.8031
Root MSE	= 1490.7

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc6					2954.222
age	35187.43	16193.62	2.173	0.066	.0964699
fh12	-.0040502	.0150744	-0.269	0.796	106585.9

Plot of Residuals fsc6

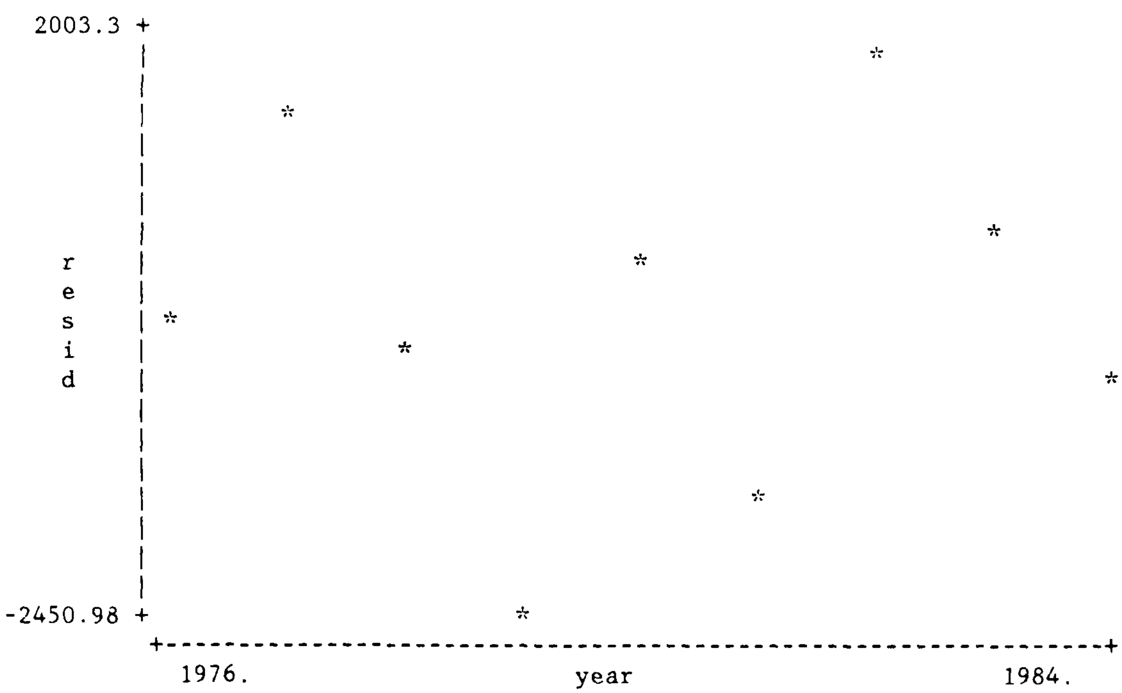

Table D.6

REGRESSION OF C-5 FSC7 ON AGE FH12

Source	SS	df	MS
Model	39183313.4	2	19591656.7
Residual	13882040.6	7	1983148.66
Total	53065354.0	9	5896150.44

Number of obs	= 9
F(2, 7)	= 9.88
Prob > F	= 0.0092
R-square	= 0.7384
Adj R-square	= 0.6637
Root MSE	= 1408.2

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc7					1952.889
age	27334.24	15297.89	1.787	0.117	.0964699
fh12	-.0063246	.0142406	-0.444	0.670	106585.9

Plot of Residuals fsc7

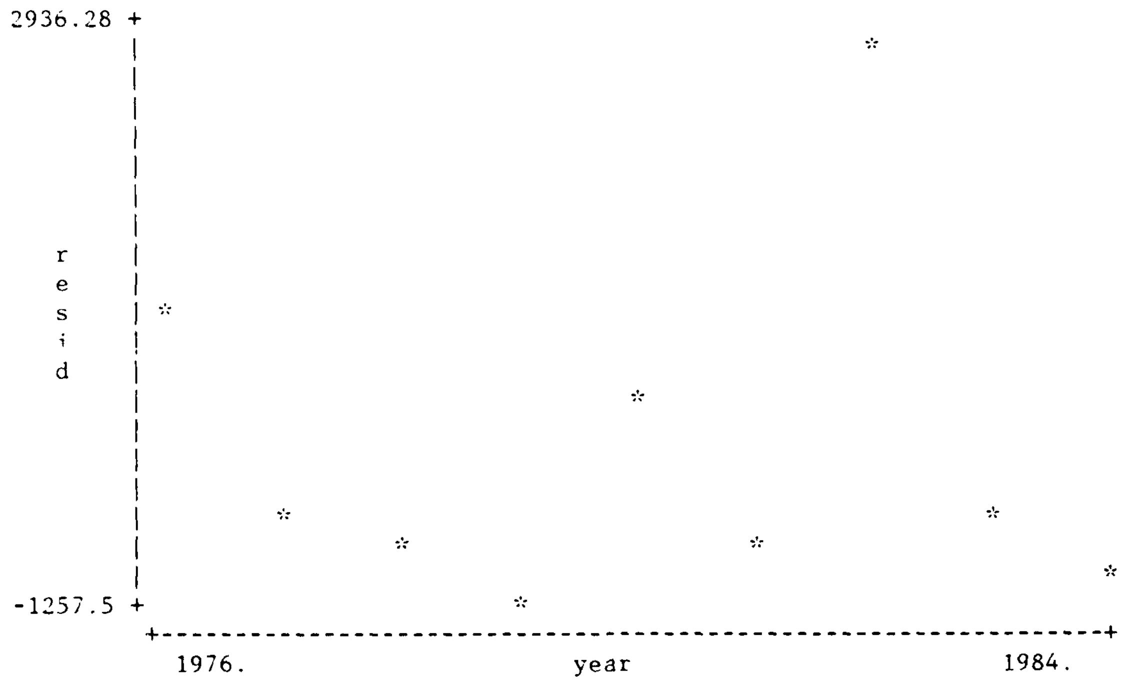

Table D.7

REGRESSION OF C-5 FSC8 ON ACE AND FH12

Source	SS	df	MS		
Model	2.2854E+09	2	1.1427E+09	Number of obs =	9
Residual	2.7798E+09	7	397110763.	F(2, 7) =	2.88
Total	5.0652E+09	9	562801777.	Prob > F =	0.1224
				R-square =	0.4512
				Adj R-square =	0.2944
				Root MSE =	19928.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc8					15454.33
age	153389.9	216476.	0.709	0.501	.0964699
fh12	.0066503	.2015139	0.033	0.975	106585.9

Plot of Residuals fsc8

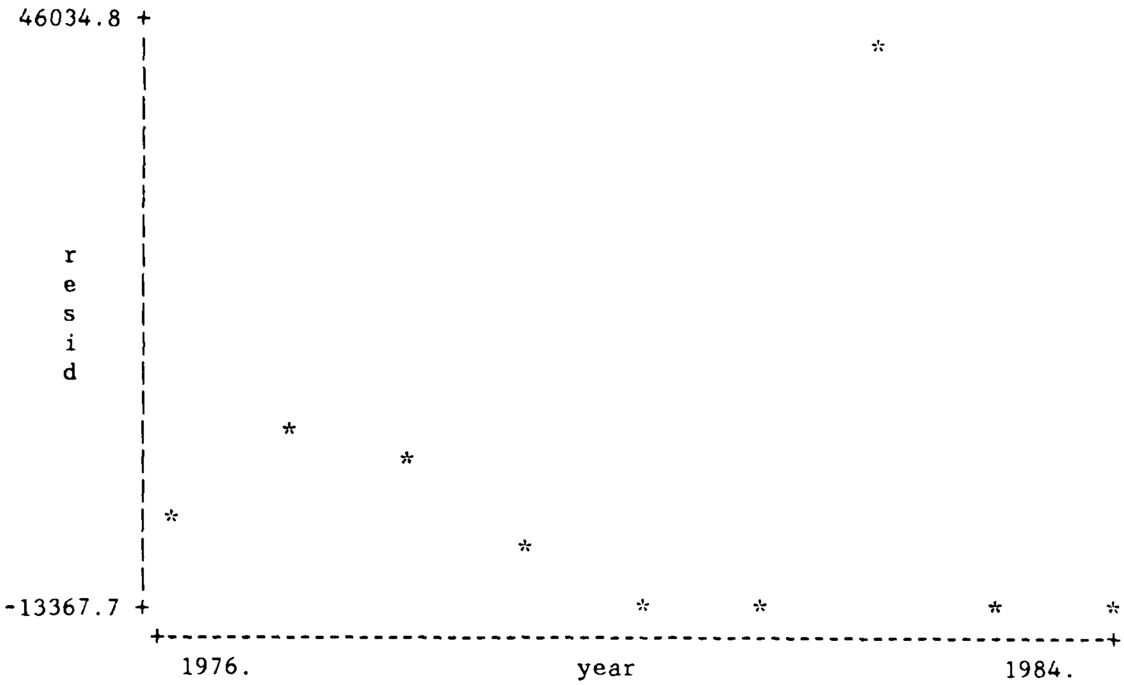

Table D.8

REGRESSION OF C-5 FSC9 ON AGE AND FH12

Source	SS	df	MS
Model	392654916.	2	196327458.
Residual	140731779.	7	20104539.9
Total	533386695.	9	59265188.3

Number of obs	=	9
F(2, 7)	=	9.77
Prob > F	=	0.0094
R-square	=	0.7362
Adj R-square	=	0.6608
Root MSE	=	4483.8

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc9					6294.333
age	77479.09	48708.08	1.591	0.156	.0964699
fh12	-.0109364	.0453415	-0.241	0.816	106585.9

Plot of Residuals fsc9

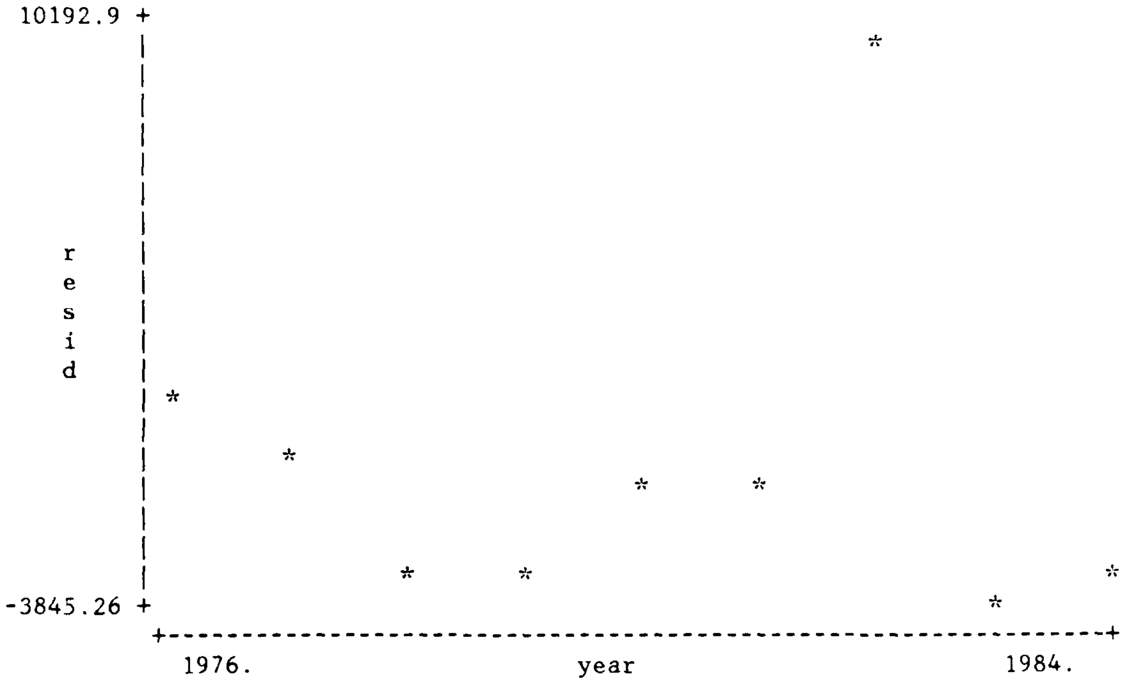

Table D.9

REGRESSION OF C-5 FSC10 ON AGE AND FH12

Source	SS	df	MS
Model	3.1419E+09	2	1.5710E+09
Residual	3.2957E+09	7	470817899.
Total	6.4377E+09	9	715296343.

Number of obs	=	9
F(2, 7)	=	3.34
Prob > F	=	0.0960
R-square	=	0.4881
Adj R-square	=	0.3418
Root MSE	=	21698.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc10					16894.56
age	298917.6	235711.3	1.268	0.245	.0964699
fh12	-.1123527	.2194197	-0.512	0.624	106585.9

Plot of Residuals fsc10

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    s    |
    i    |
    d    |
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         |                                          *
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-19650.7 +                 *       *
          +-----------------------------------------------------------------+
            1976.                     year                          1984.
```

Table D.10

REGRESSION OF C-5 FSC11 ON AGE AND FH12

Source	SS	df	MS
Model	754085606.	2	377042803.
Residual	532482781.	7	76068968.7
Total	1.2866E+09	9	142952043.

Number of obs	=	9
F(2, 7)	=	4.96
Prob > F	=	0.0456
R-square	=	0.5861
Adj R-square	=	0.4679
Root MSE	=	8721.8

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscl1					8380.333
age	139016.1	94745.3	1.467	0.186	.0964699
fh12	-.0473055	.0881968	-0.536	0.608	106585.9

Plot of Residuals fscl1

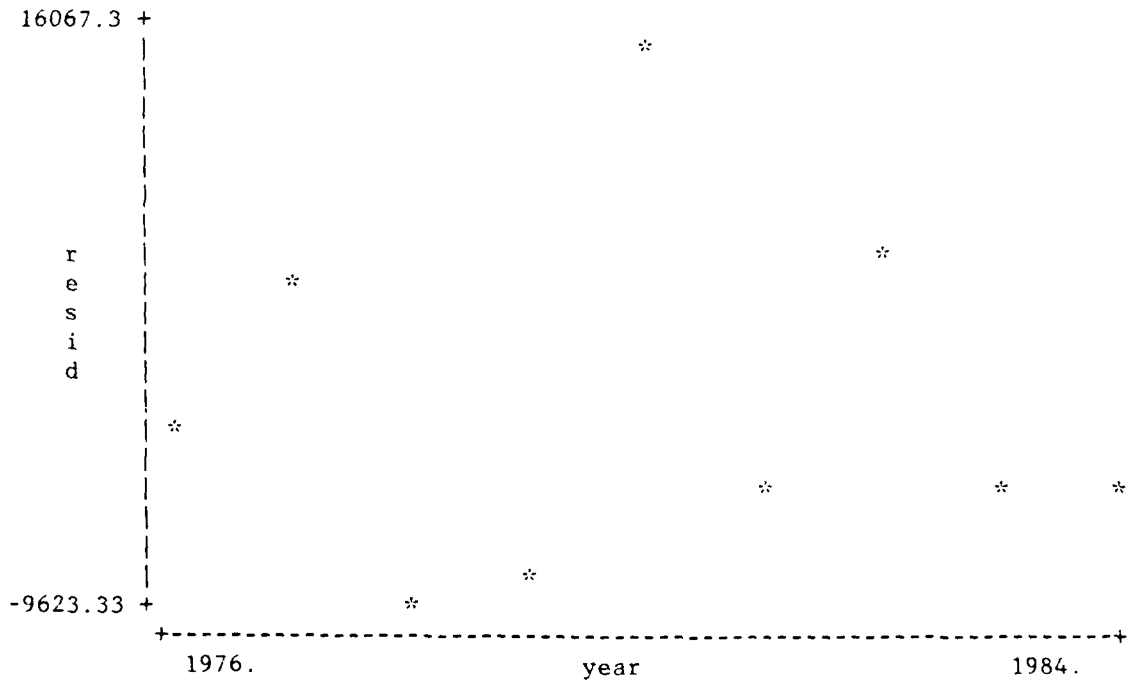

Table D.11

REGRESSION OF C-5 FSC12 ON AGE AND FH12

Source	SS	df	MS
Model	1.1017E+09	2	550849051.
Residual	890794538.	7	127256363.
Total	1.9925E+09	9	221388071.

Number of obs =	9
F(2, 7) =	4.33
Prob > F =	0.0597
R-square =	0.5529
Adj R-square =	0.4252
Root MSE =	11281.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc12					7461.222
age	277339.8	122544.5	2.263	0.058	.0964699
fh12	-.179415	.1140746	-1.573	0.160	106585.9

Plot of Residuals fsc12

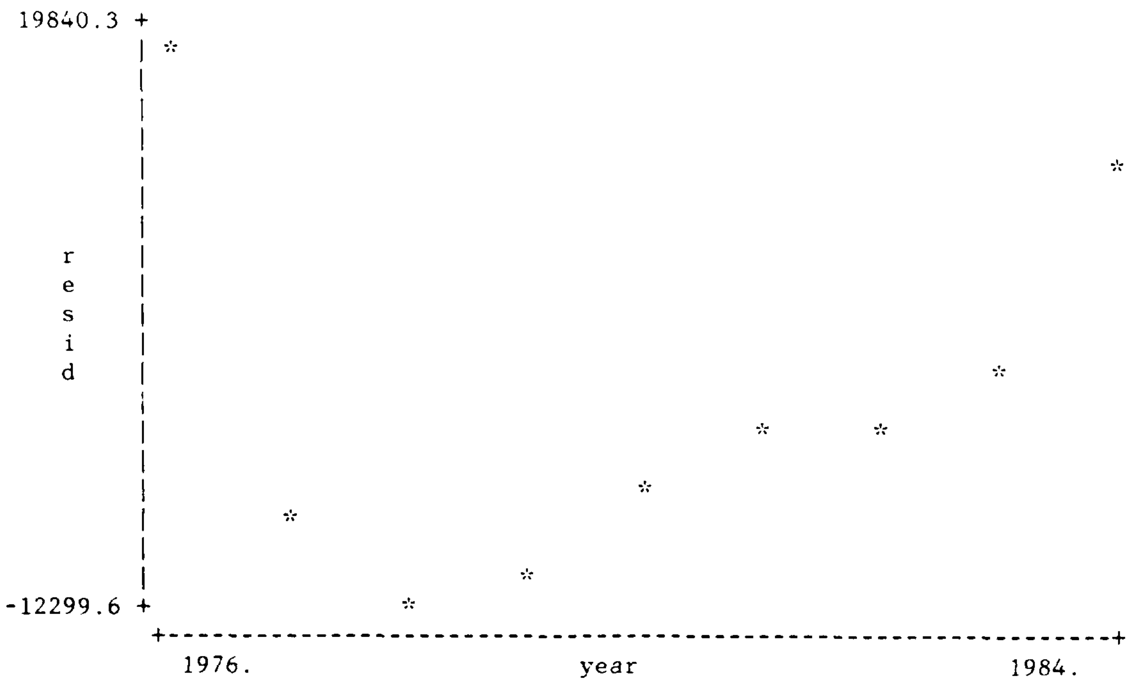

Table D.12

REGRESSION OF C-5 FSC13 ON AGE AND FH12

```
   Source|       SS          df        MS                Number of obs =       9
---------+-----------------------------                F(  2,      7) =    5.54
    Model|  747216271.       2   373608135.            Prob > F       =  0.0361
 Residual|  471776412.       7   67396630.3            R-square       =  0.6130
---------+-----------------------------                Adj R-square   =  0.5024
    Total|  1.2190E+09       9   135443631.            Root MSE       =  8209.5

 Variable| Coefficient    Std. Error       t       Prob > |t|       Mean
---------+---------------------------------------------------------------------
    fsc13|                                                          9048.556
---------+---------------------------------------------------------------------
      age|    -24909.03      89181.13    -0.279      0.788         .0964699
     fh12|     .1070264      .0830172     1.289      0.238         106585.9
---------+---------------------------------------------------------------------
```

Plot of Residuals fscl3

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  17479. +
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    r    |
    e    |
    s    |
    i    |
    d    |                                                 *       *
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         |                 *       *
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-10155.4 +                                                                 *
          +----------------------------------------------------------------+
            1976.                      year                            1984.
```

Table D.13

REGRESSION OF C-5 FSC14 ON AGE AND FH12

Source	SS	df	MS
Model	133354939.	2	66677469.4
Residual	63403079.2	7	9057582.74
Total	196758018.	9	21862002.0

Number of obs	=	9
F(2, 7)	=	7.36
Prob > F	=	0.0190
R-square	=	0.6778
Adj R-square	=	0.5857
Root MSE	=	3009.6

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc14					3833.556
age	657.1208	32693.4	0.020	0.985	.0964699
fh12	.0354406	.0304337	1.165	0.282	106585.9

Plot of Residuals fsc14

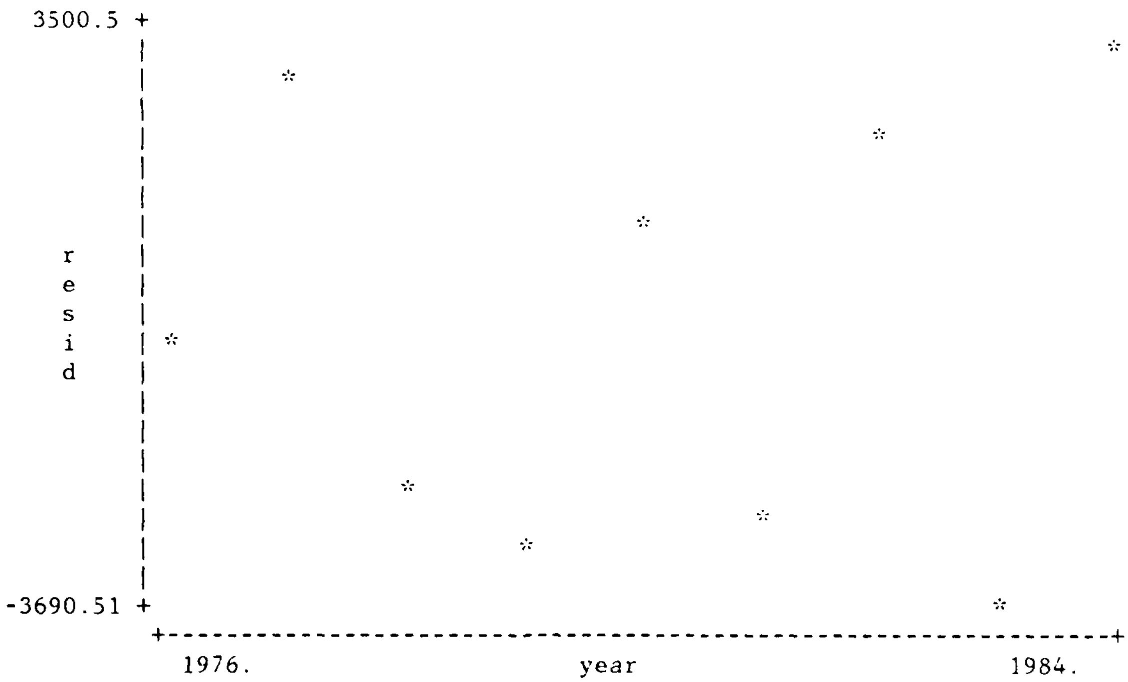

Table D.14

REGRESSION OF C-5 FSCSUM ON AGE AND FH12

Source	SS	df	MS
Model	7.9874E+10	2	3.9937E+10
Residual	1.1213E+10	7	1.6018E+09
Total	9.1086E+10	9	1.0121E+10

Number of obs	=	9
F(2, 7)	=	24.93
Prob > F	=	0.0007
R-square	=	0.8769
Adj R-square	=	0.8417
Root MSE	=	40023.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					87788.78
age	1281407.	434770.8	2.947	0.021	.0964699
fh12	-.33352	.404721	-0.824	0.437	106585.9

Plot of Residuals fscsum

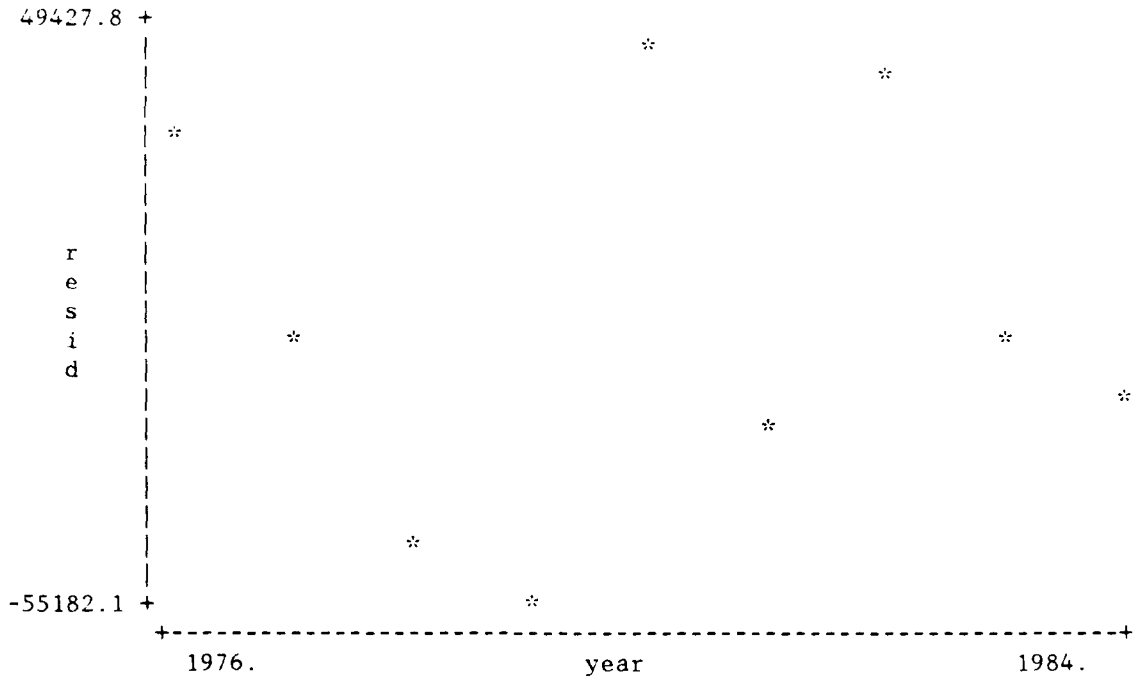

Table D.15

REGRESSION OF C-5 FSC8 ON AGE AND FH12

Source	SS	df	MS
Model	1.5220E+09	2	761009367.
Residual	211535826.	7	30219403.7
Total	1.7336E+09	9	192617173.

Number of obs	=	9
F(2, 7)	=	25.18
Prob > F	=	0.0006
R-square	=	0.8780
Adj R-square	=	0.8431
Root MSE	=	5497.2

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc8					10062.22
age	290082.3	59716.84	4.858	0.002	.0964699
fh12	-.168141	.0555894	-3.025	0.019	106585.9

Plot of Residuals fsc8

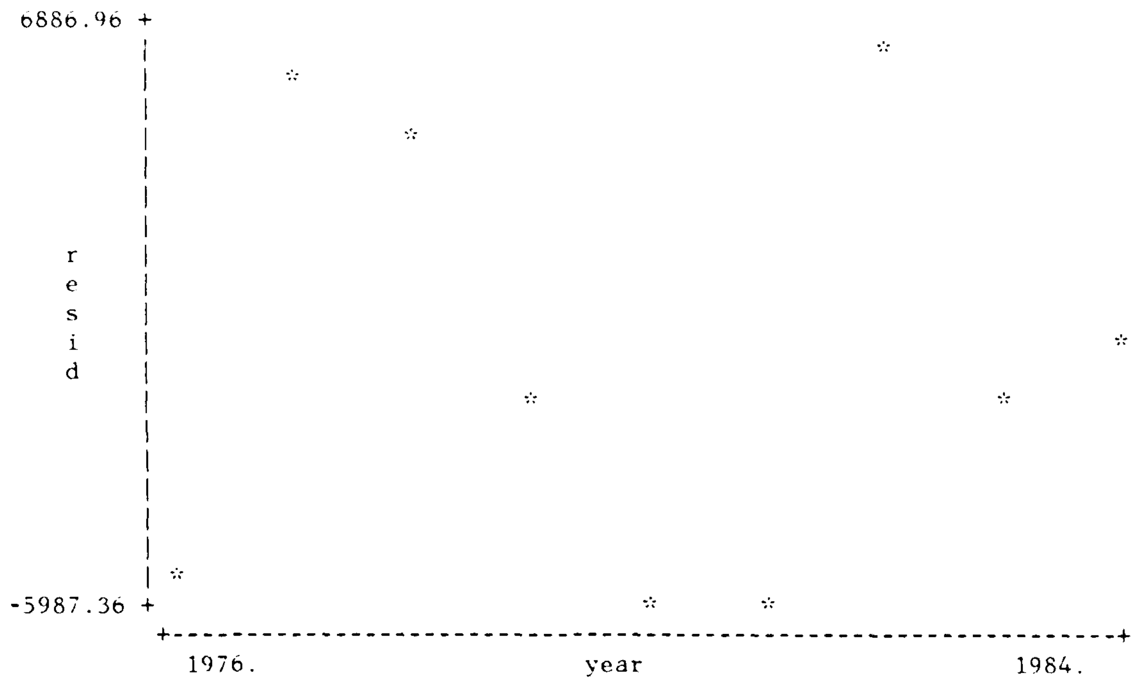

Table D.16

REGRESSION OF C-5 FSC9 ON AGE AND FH12 WITH OUTLIERS REMOVED

```
  Source|       SS         df        MS             Number of obs =       9
---------+-----------------------------             F(  2,     7) =   59.04
   Model|  319427928.      2  159713964.            Prob > F      =  0.0000
Residual|  18937827.4      7  2705403.91            R-square      =  0.9440
---------+-----------------------------             Adj R-square  =  0.9280
   Total|  338365755.      9  37596195.0            Root MSE      =  1644.8

Variable| Coefficient    Std. Error       t     Prob > |t|       Mean
---------+---------------------------------------------------------------
    fsc9|                                                      5217.667
---------+---------------------------------------------------------------
     age|    104773.1      17867.75     5.864     0.001        .0964699
    fh12|   -.0458378      .0166328    -2.756     0.028        106585.9
---------+---------------------------------------------------------------
```

Plot of Residuals fsc9

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  2376.11 +
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    i     |
    d     |                                                                 *
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          |                         *                               *
 -2085.03 +                 *
           +-----------------------------------------------------------------+
            1976.                       year                         1984.
```

Table D.17

REGRESSION OF C-5 FSC10 ON AGE AND FH12

Source	SS	df	MS
Model	1.8001E+09	2	900058147.
Residual	537856633.	7	76836661.9
Total	2.3380E+09	9	259774770.

Number of obs	=	9
F(2, 7)	=	11.71
Prob > F	=	0.0058
R-square	=	0.7699
Adj R-square	=	0.7042
Root MSE	=	8765.7

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc10					10887.89
age	313775.1	95222.19	3.295	0.013	.0964699
fh12	-.1808996	.0886408	-2.041	0.081	106585.9

Plot of Residuals fsc10

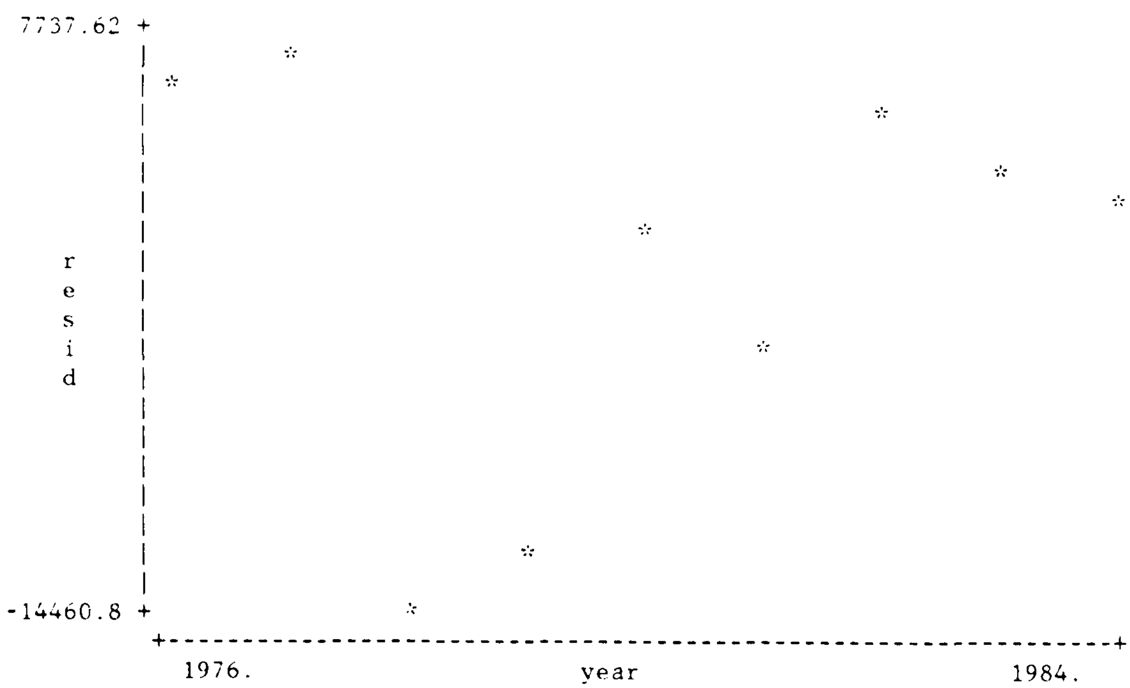

Table D.18

REGRESSION OF C-5 FSCSUM ON AGE AND FH12 WITH FSC5 REMOVED

Source	SS	df	MS		
				Number of obs =	9
				F(2, 7) =	24.25
Model	6.7272E+10	2	3.3636E+10	Prob > F =	0.0007
Residual	9.7111E+09	7	1.3873E+09	R-square =	0.8739
				Adj R-square =	0.8378
Total	7.6983E+10	9	8.5537E+09	Root MSE =	37246.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					80123.33
age	1206942.	404612.5	2.983	0.020	.0964699
fh12	-.3376404	.3766471	-0.896	0.400	106585.9

Plot of Residuals fscsum with fsc5 deleted

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 40979.9 +
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    e    |         *                                               *
    s    |
    i    |
    d    |                                                                 *
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-51524.6 +                 *       *
          +-----------------------------------------------------------------+
            1976.                      year                         1984.
```

Table D.19

REGRESSION OF C-5 FSCSUM ON AGE AND FH12 WITH FSC5 AND FSC12 REMOVED

Source	SS	df	MS		
				Number of obs =	9
				F(2, 7) =	23.94
Model	5.2758E+10	2	2.6379E+10	Prob > F =	0.0007
Residual	7.7127E+09	7	1.1018E+09	R-square =	0.8725
				Adj R-square =	0.8360
Total	6.0471E+10	9	6.7190E+09	Root MSE =	33194.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					72662.11
age	929602.5	360584.6	2.578	0.037	.0964699
fh12	-.1582255	.3356622	-0.471	0.652	106585.9

Plot of Residuals fscsum with fsc5 and fsc12 deleted

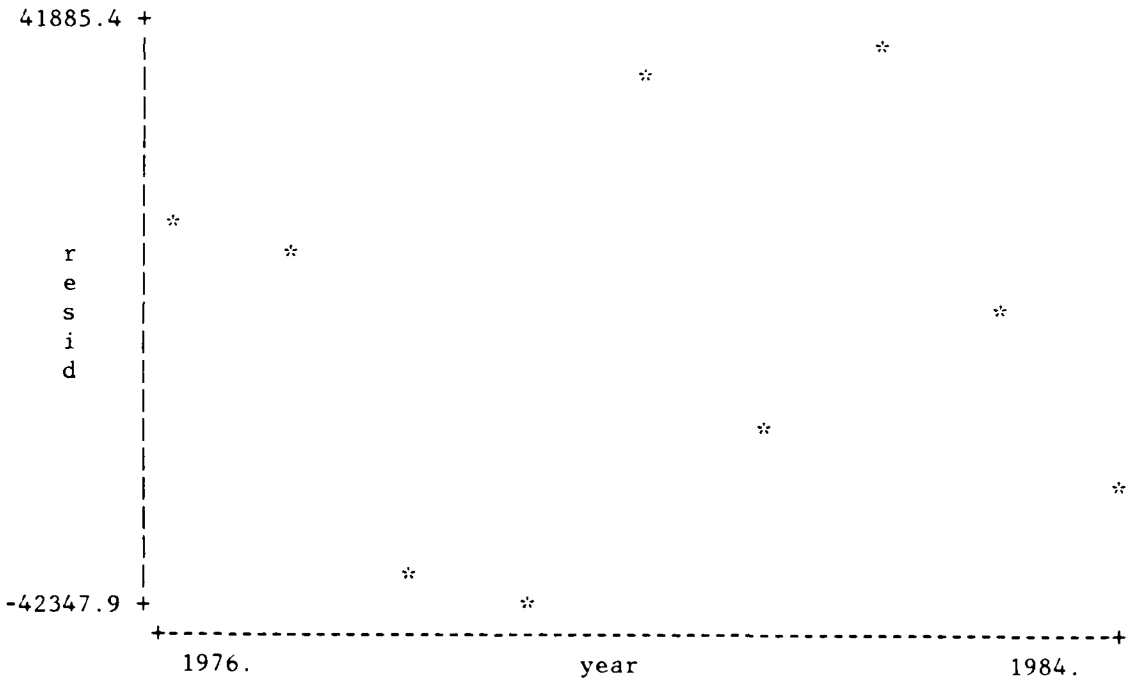

Table D.20

REGRESSION OF C-5 FSCSUM ON AGE AND FH12 WITH FSC5, 12, AND 3 REMOVED

Source	SS	df	MS
Model	4.0173E+10	2	2.0087E+10
Residual	6.6773E+09	7	953901520.
Total	4.6851E+10	9	5.2056E+09

Number of obs =	9
F(2, 7) =	21.06
Prob > F =	0.0011
R-square =	0.8575
Adj R-square =	0.8168
Root MSE =	30885.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					62644.
age	891054.9	335510.2	2.656	0.033	.0964699
fh12	-.218536	.3123208	-0.700	0.507	106585.9

Plot of Residuals fscsum with fsc5, 12, and 3 deleted

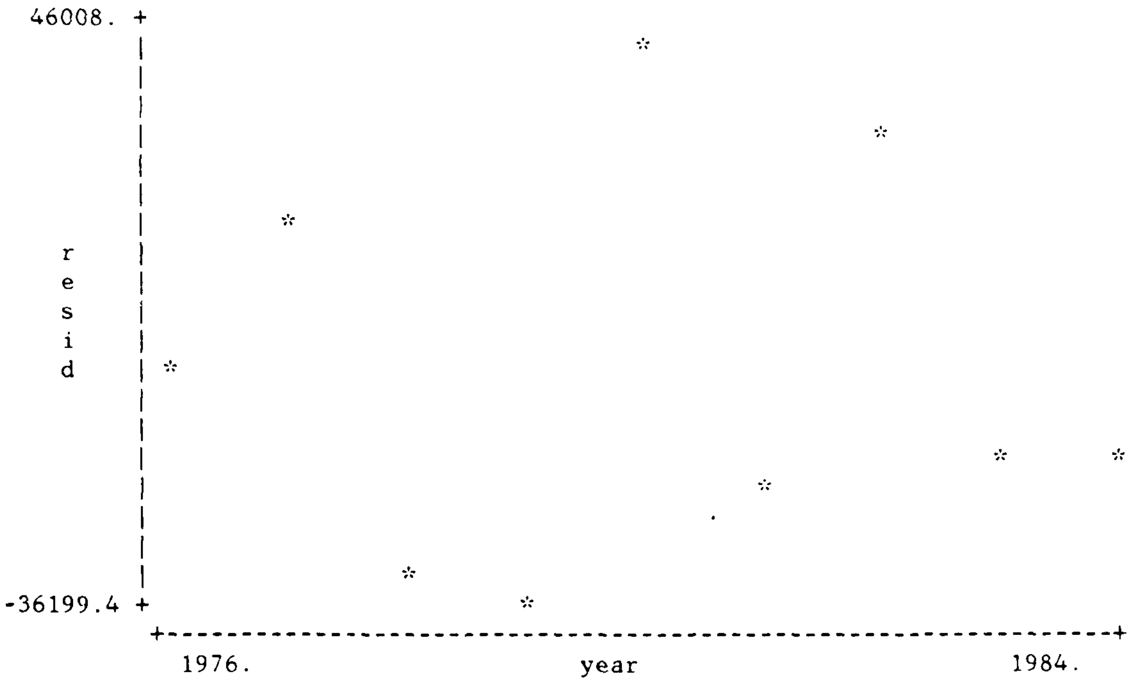

Table D.21

REGRESSION OF C-5 FSCSUM ON AGE AND FH12 WITH FSC5, 12, 3, AND 11 REMOVED

Source	SS	df	MS
Model	2.9941E+10	2	1.4971E+10
Residual	3.5460E+09	7	506574963.
Total	3.3487E+10	9	3.7208E+09

Number of obs	=	9
F(2, 7)	=	29.55
Prob > F	=	0.0004
R-square	=	0.8941
Adj R-square	=	0.8639
Root MSE	=	22507.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					54263.67
age	752038.8	244498.3	3.076	0.018	.0964699
fh12	-.1712305	.2275994	-0.752	0.476	106585.9

Plot of Residuals fscsum with fsc5, 12, 3, & 11 deleted

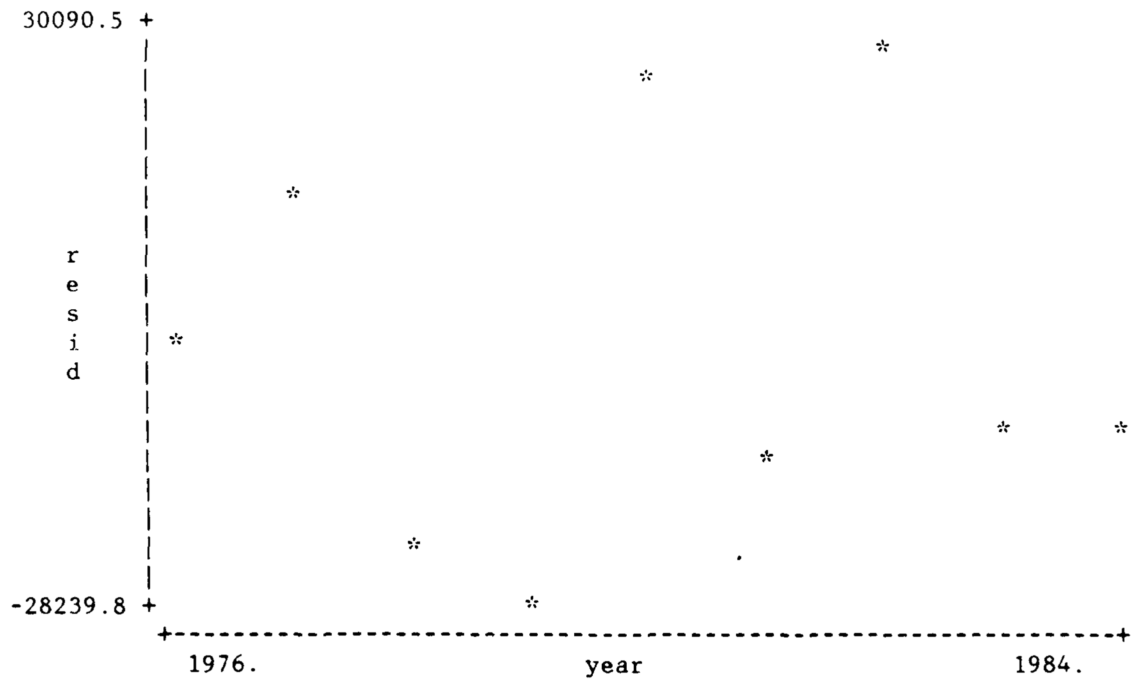

Table D.22

REGRESSION OF F-15 FSCSUM ON AGE AND FH12

Source	SS	df	MS
Model	1.7340E+12	2	8.6701E+11
Residual	4.0262E+11	5	8.0524E+10
Total	2.1366E+12	7	3.0523E+11

Number of obs	=	7
F(2, 5)	=	10.77
Prob > F	=	0.0154
R-square	=	0.8116
Adj R-square	=	0.7362
Root MSE	=	2.8E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					489407.7
age	1064157.	653178.4	1.629	0.164	.2717677
fh12	.6745131	.6265694	1.077	0.331	300033.

Plot of Residuals fscsum

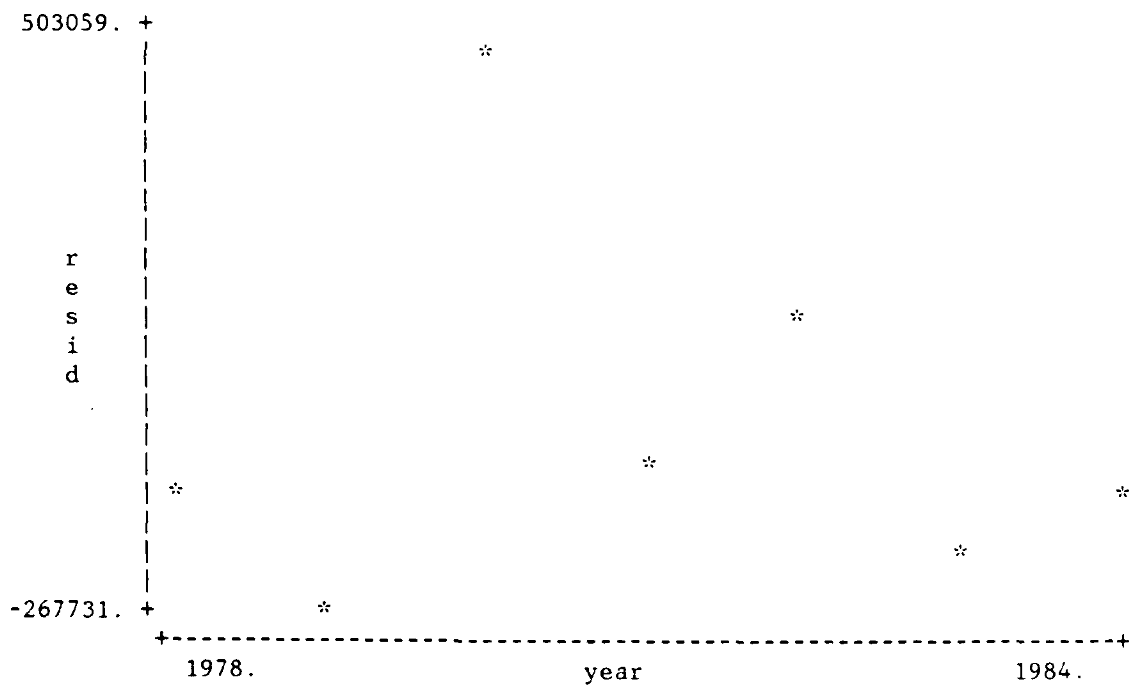

Table D.23

REGRESSION OF F-15 FSC1 ON AGE AND FH12

Source	SS	df	MS
Model	205573.416	2	102786.708
Residual	233874.584	5	46774.9168
Total	439448.00	7	62778.2857

Number of obs	=	7
F(2, 5)	=	2.20
Prob > F	=	0.2066
R-square	=	0.4678
Adj R-square	=	0.2549
Root MSE	=	216.28

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscl					170.8571
age	204.6106	497.8248	0.411	0.698	.2717677
fh12	.0003857	.0004775	0.808	0.456	300033.

Plot of Residuals fscl

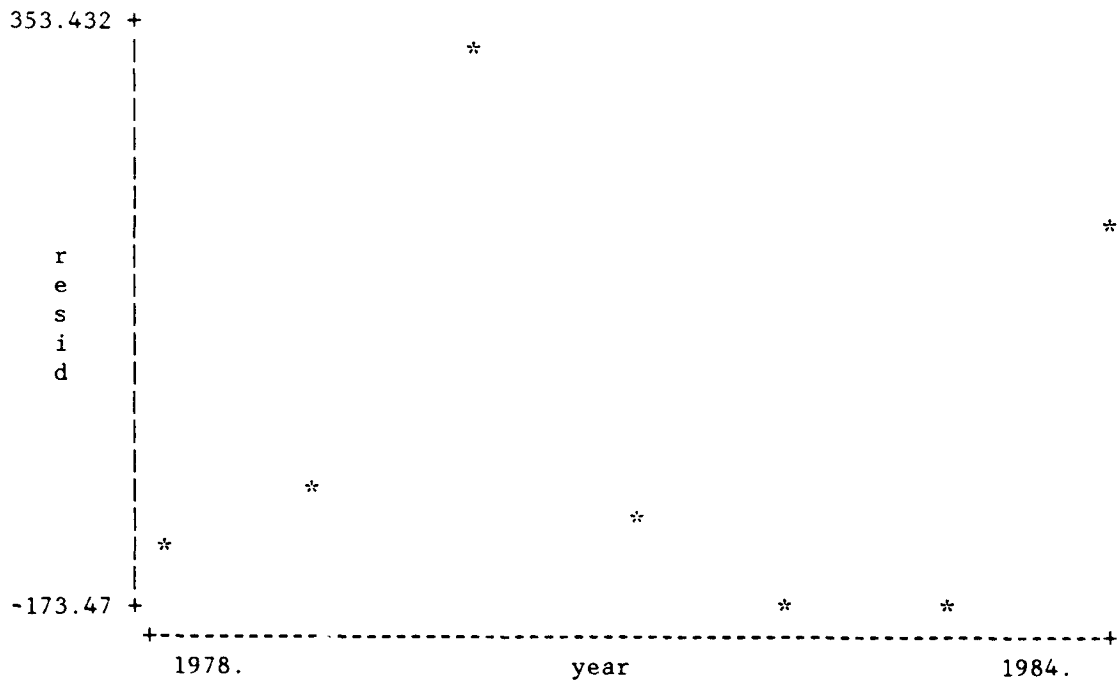

Table D.24

REGRESSION OF F-15 FSC2 ON AGE AND FH12

Source	SS	df	MS
Model	303497846.	2	151748923.
Residual	122276960.	5	24455392.0
Total	425774806.	7	60824972.3

Number of obs	=	7
F(2, 5)	=	6.21
Prob > F	=	0.0442
R-square	=	0.7128
Adj R-square	=	0.5979
Root MSE	=	4945.2

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc2					6497.143
age	12298.93	11383.02	1.080	0.329	.2717677
fh12	.0106717	.0109193	0.977	0.373	300033.

Plot of Residuals fsc2

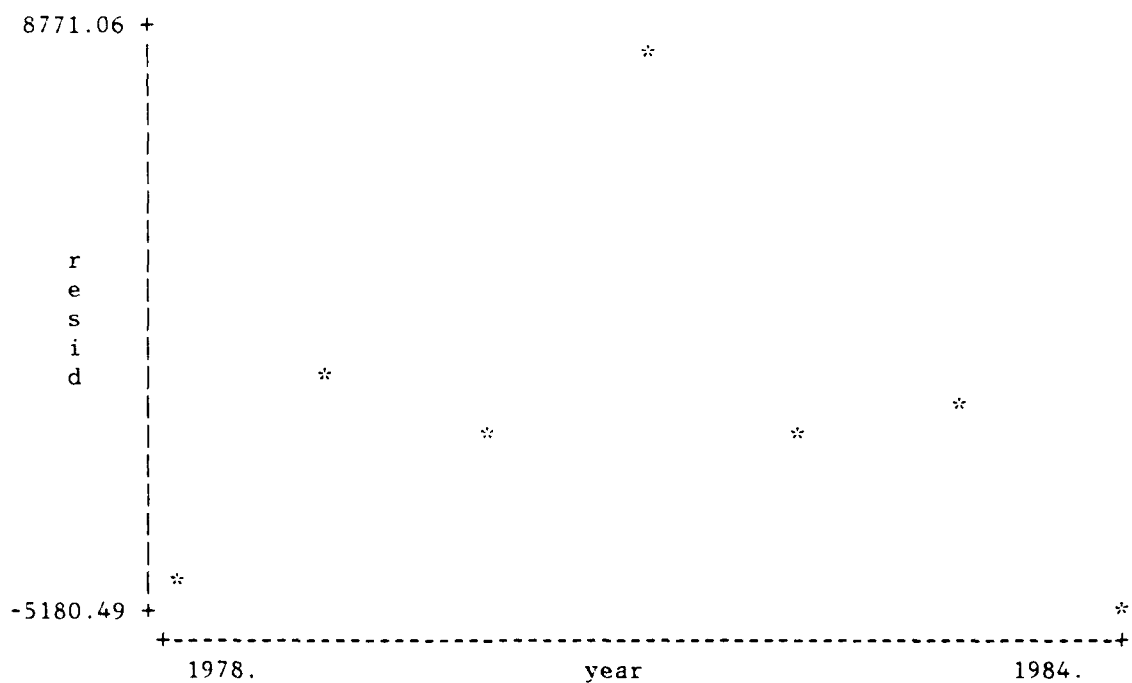

Table D.25

REGRESSION OF F-15 FSC3 ON AGE AND FH12

Source	SS	df	MS
Model	1.7299E+10	2	8.6497E+09
Residual	1.5635E+10	5	3.1270E+09
Total	3.2934E+10	7	4.7049E+09

Number of obs	=	7
F(2, 5)	=	2.77
Prob > F	=	0.1553
R-square	=	0.5253
Adj R-square	=	0.3354
Root MSE	=	55919.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc3					49629.
age	43310.72	128715.6	0.336	0.750	.2717677
fh12	.1261366	.123472	1.022	0.354	300033.

Plot of Residuals fsc3

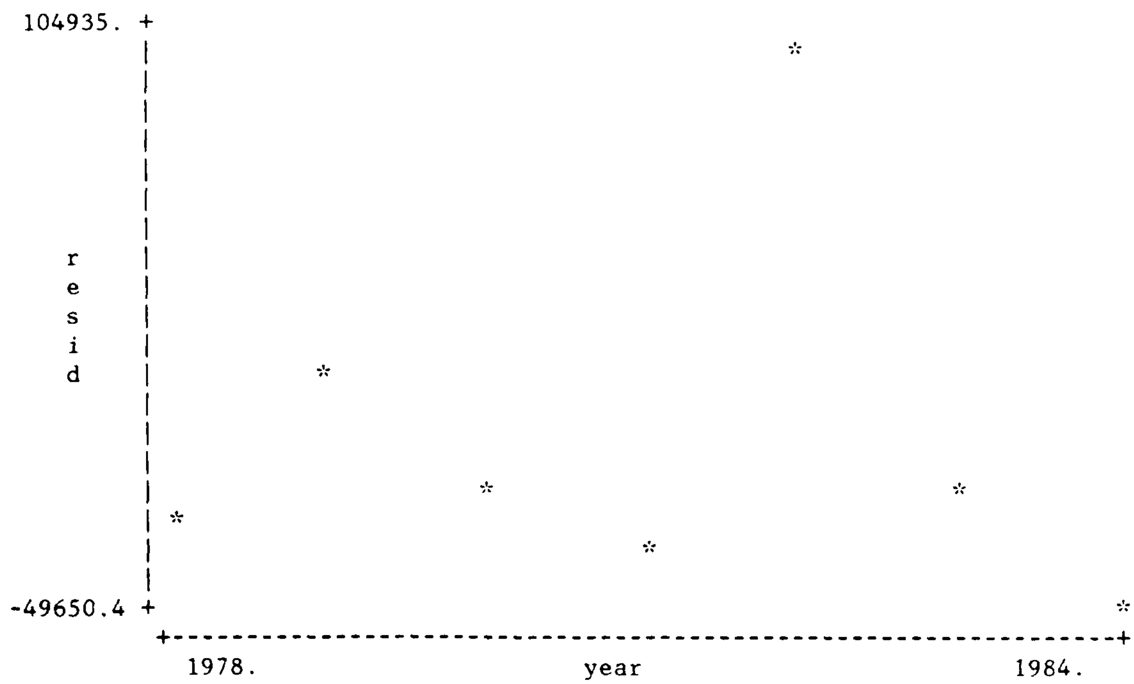

Table D.26

REGRESSION OF F-15 FSC4 ON AGE AND FH12

Source	SS	df	MS
Model	7.5816E+09	2	3.7908E+09
Residual	6.7075E+09	5	1.3415E+09
Total	1.4289E+10	7	2.0413E+09

Number of obs	=	7
F(2, 5)	=	2.83
Prob > F	=	0.1510
R-square	=	0.5306
Adj R-square	=	0.3428
Root MSE	=	36627.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc4					28820.43
age	129068.4	84307.52	1.531	0.186	.2717677
fh12	-.0205021	.080873	-0.254	0.810	300033.

Plot of Residuals fsc4

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  74076.6 +
          |                      *
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     r    |
     e    |
     s    |
     i    |
     d    |
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          |                                                                 *
          |                                           *          *
          |           *                     *
          |
 -26228.6 + *
           +------------------------------------------------------------------+
             1978.                        year                        1984.
```

Table D.27

REGRESSION OF F-15 FSC5 ON AGE AND FH12

Source	SS	df	MS
Model	2.9041E+09	2	1.4520E+09
Residual	831253029.	5	166250606.
Total	3.7353E+09	7	533619413.

Number of obs =	7
F(2, 5) =	8.73
Prob > F =	0.0234
R-square =	0.7775
Adj R-square =	0.6884
Root MSE =	12894.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc5					20295.71
age	33386.49	29679.16	1.125	0.312	.2717677
fh12	.0374678	.0284701	1.316	0.245	300033.

Plot of Residuals fsc5

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 22046.9 +
         |                                                 *
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         |
       r |
       e |
       s |
       i | *
       d |
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         |                                                           *
         |
         |
         |
         |
-10344.6 +          *                   *                             *
          +-----------------------------------------------------------+
           1978.                     year                         1984.
```

Table D.28

REGRESSION OF F-15 FSC6 ON AGE AND FH12

Source	SS	df	MS
Model	35027540.7	2	17513770.3
Residual	4203371.34	5	840674.268
Total	39230912.0	7	5604416.00

Number of obs	=	7
F(2, 5)	=	20.83
Prob > F	=	0.0038
R-square	=	0.8929
Adj R-square	=	0.8500
Root MSE	=	916.88

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc6					2222.
age	1148.242	2110.493	0.544	0.610	.2717677
fh12	.0063619	.0020245	3.142	0.026	300033.

Plot of Residuals fsc6

```
 1486.81 +
         |                                                       *
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         |
         |
         |
         |
    r    |                                  *
    e    |
    s    |
    i    |
    d    | *
         |           *           *
         |
         |                                            *
         |
         |
         |
         |
-1218.58 +                                                                  *
          +-----------------------------------------------------------------+
            1978.                  year                         1984.
```

Table D.29

REGRESSION OF F-15 FSC7 ON AGE AND FH12

Source	SS	df	MS
Model	2.1268E+09	2	1.0634E+09
Residual	507502902.	5	101500580.
Total	2.6343E+09	7	376332158.

Number of obs	= 7
F(2, 5)	= 10.48
Prob > F	= 0.0163
R-square	= 0.8073
Adj R-square	= 0.7303
Root MSE	= 10075.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc7					17202.14
age	4606.672	23190.19	0.199	0.850	.2717677
fh12	.0531757	.0222455	2.390	0.062	300033.

Plot of Residuals fsc7

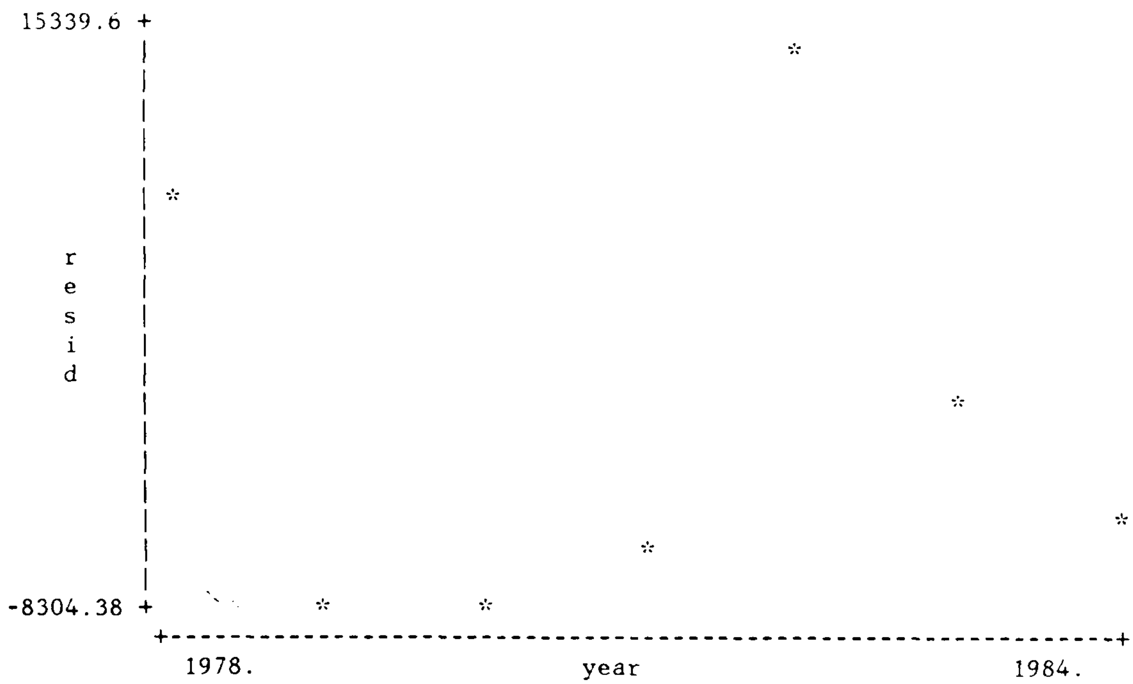

Table D.30

REGRESSION OF F-15 FSC9 ON AGE AND FH12

Source	SS	df	MS
Model	714593039.	2	357296520.
Residual	37919763.7	5	7583952.74
Total	752512803.	7	107501829.

Number of obs =	7
F(2, 5) =	47.11
Prob > F =	0.0006
R-square =	0.9496
Adj R-square =	0.9295
Root MSE =	2753.9

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc9					9900.714
age	23126.45	6338.957	3.648	0.015	.2717677
fh12	.0121619	.0060807	2.000	0.102	300033.

Plot of Residuals fsc9

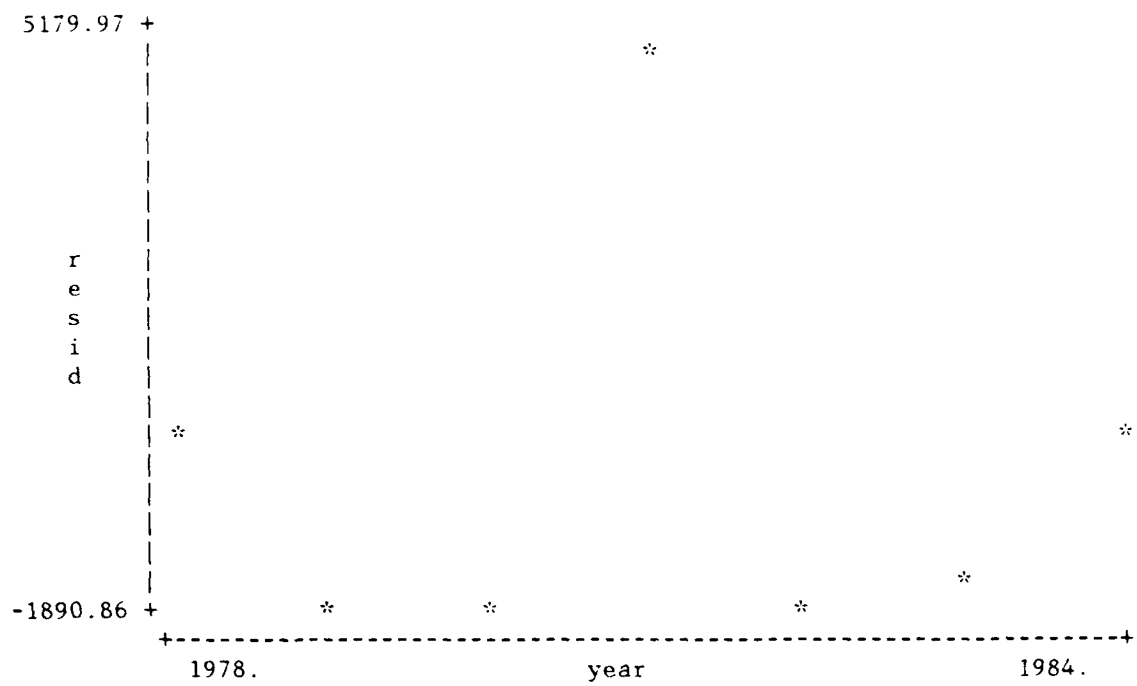

Table D.31

REGRESSION OF F-15 FSC10 ON AGE AND FH12

Source	SS	df	MS
Model	5.9229E+09	2	2.9615E+09
Residual	1.0973E+09	5	219465903.
Total	7.0203E+09	7	1.0029E+09

Number of obs	= 7
F(2, 5)	= 13.49
Prob > F	= 0.0097
R-square	= 0.8437
Adj R-square	= 0.7812
Root MSE	= 14814.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc10					26670.57
age	100906.	34099.94	2.959	0.032	.2717677
fh12	-.0022412	.0327108	-0.069	0.948	300033.

Plot of Residuals fsc10

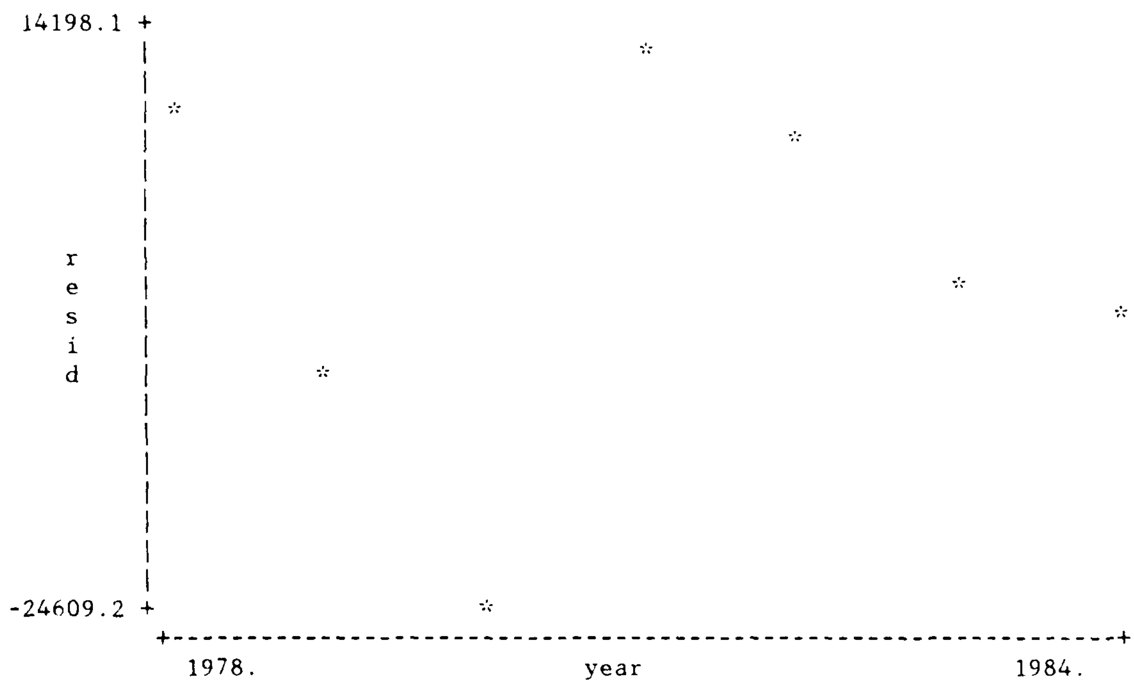

Table D.32

REGRESSION OF F-15 FSC11 ON AGE AND FH12

Source	SS	df	MS
Model	5.7740E+11	2	2.8870E+11
Residual	1.9378E+11	5	3.8756E+10
Total	7.7118E+11	7	1.1017E+11

Number of obs	=	7
F(2, 5)	=	7.45
Prob > F	=	0.0317
R-square	=	0.7487
Adj R-square	=	0.6482
Root MSE	=	2.0E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc11					280386.1
age	667450.6	453145.4	1.473	0.201	.2717677
fh12	.3354913	.4346853	0.772	0.475	300033.

Plot of Residuals fsc11

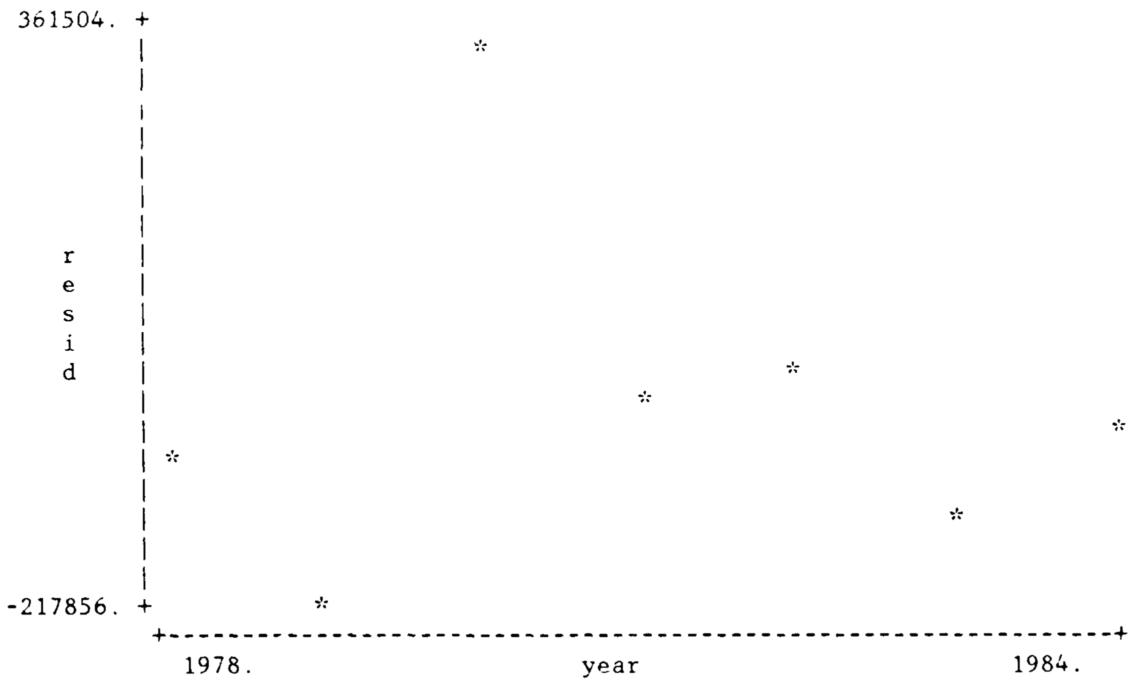

Table D.33

REGRESSION OF F-15 FSC12 ON AGE AND FH12

Source	SS	df	MS
Model	55513452.5	2	27756726.2
Residual	55179322.5	5	11035864.5
Total	110692775.	7	15813253.6

Number of obs	=	7
F(2, 5)	=	2.52
Prob > F	=	0.1754
R-square	=	0.5015
Adj R-square	=	0.3021
Root MSE	=	3322.0

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc12					2657.286
age	-1447.916	7646.685	-0.189	0.857	.2717677
fh12	.0103109	.0073352	1.406	0.219	300033.

Plot of Residuals fsc12

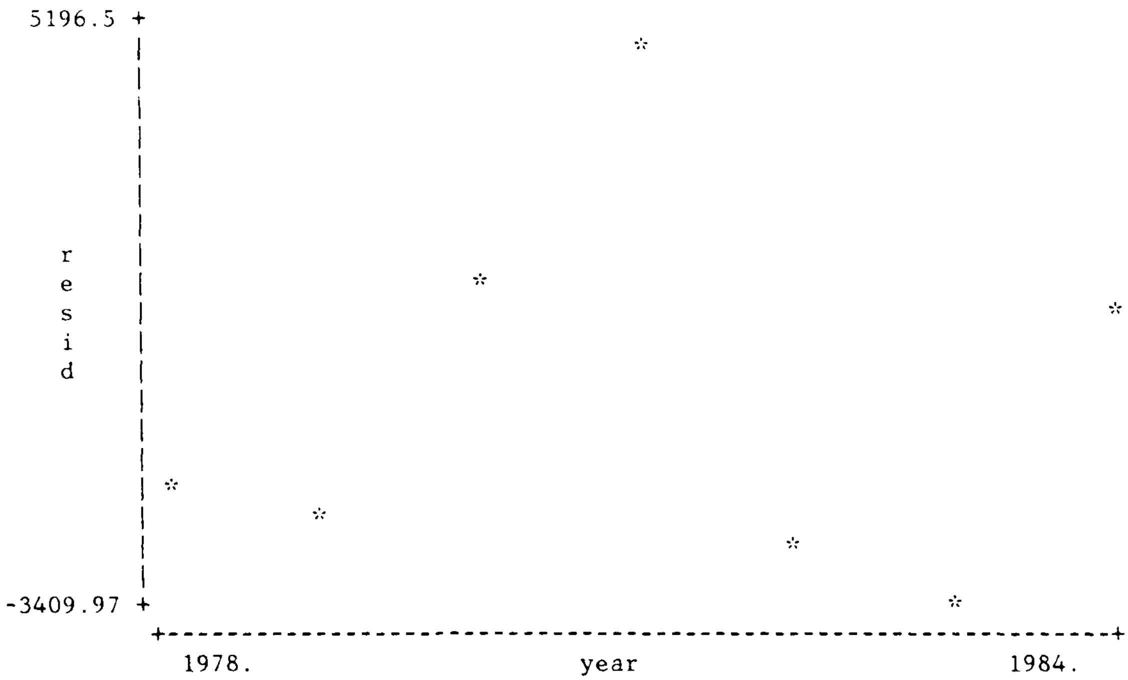

Table D.34

REGRESSION OF F-15 FSC13 ON AGE AND FH12

Source	SS	df	MS
Model	561710089.	2	280855044.
Residual	374900933.	5	74980186.7
Total	936611022.	7	133801575.

Number of obs =	7
F(2, 5) =	3.75
Prob > F =	0.1014
R-square =	0.5997
Adj R-square =	0.4396
Root MSE =	8659.1

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc13					8946.286
age	11276.77	19931.65	0.566	0.596	.2717677
fh12	.0196358	.0191197	1.027	0.352	300033.

Plot of Residuals fsc13

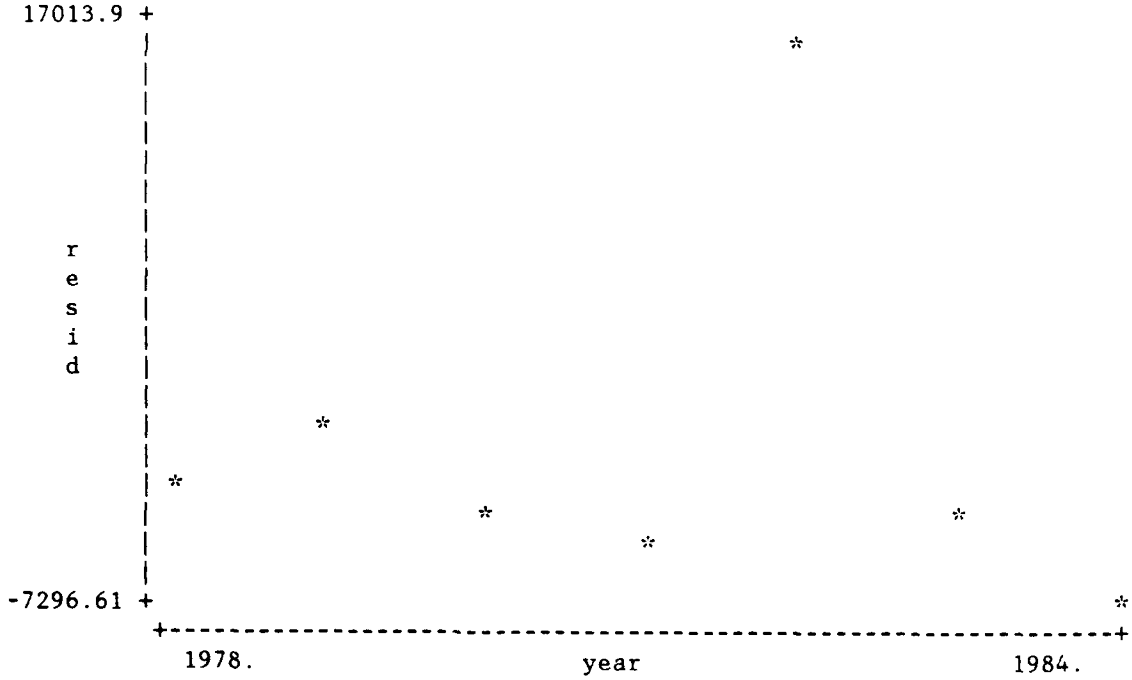

Table D.35

REGRESSION OF F-15 FSC14 ON AGE AND FH12

(obs=7)

Source	SS	df	MS
Model	9.1778E+09	2	4.5889E+09
Residual	1.6157E+10	5	3.2315E+09
Total	2.5335E+10	7	3.6193E+09

Number of obs	=	7
F(2, 5)	=	1.42
Prob > F	=	0.3248
R-square	=	0.3623
Adj R-square	=	0.1072
Root MSE	=	56846.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc14					36009.43
age	38820.77	130848.6	0.297	0.779	.2717677
fh12	.0854571	.1255182	0.681	0.526	300033.

Plot of Residuals fsc14

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 112535. +
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     r   |
     e   |
     s   |
     i   |
     d   |
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         |
         |                                         *
 -31798. + *       *                   *                 *
          +-----------------------------------------------------+
          1978.                     year                   1984.
```

Table D.36

REGRESSION OF F-15 FSCSUM ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	1.0732E+12	2	5.3658E+11
Residual	9.1454E+10	5	1.8291E+10
Total	1.1646E+12	7	1.6637E+11

Number of obs	=	7
F(2, 5)	=	29.34
Prob > F	=	0.0017
R-square	=	0.9215
Adj R-square	=	0.8901
Root MSE	=	1.4E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					388483.9
age	699777.7	311305.2	2.248	0.074	.2717677
fh12	.6650187	.2986233	2.227	0.076	300033.

Plot of Residuals, fscsum

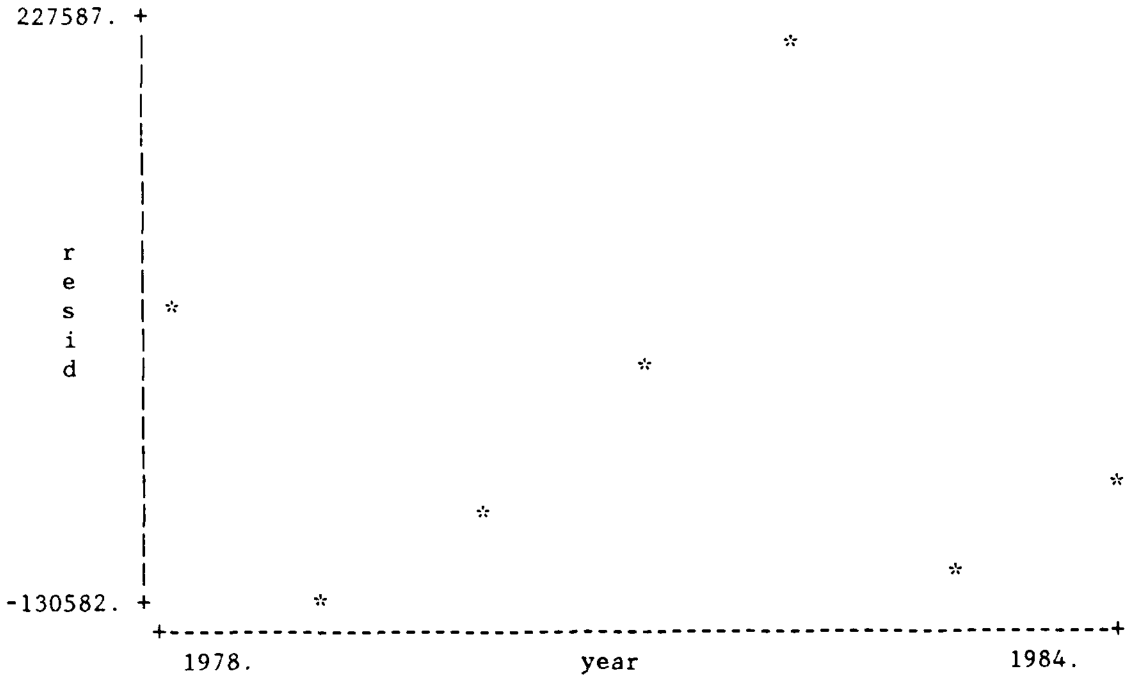

Table D.37

REGRESSION OF F-15 FSC4 ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	2.3120E+09	2	1.1560E+09
Residual	103019745.	5	20603949.0
Total	2.4150E+09	7	345006957.

Number of obs	=	7
F(2, 5)	=	56.11
Prob > F	=	0.0004
R-square	=	0.9573
Adj R-square	=	0.9403
Root MSE	=	4539.2

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc4					15284.67
age	77532.35	10448.29	7.421	0.001	.2717677
fh12	-.0193495	.0100227	-1.931	0.111	300033.

Plot of Residuals fsc4

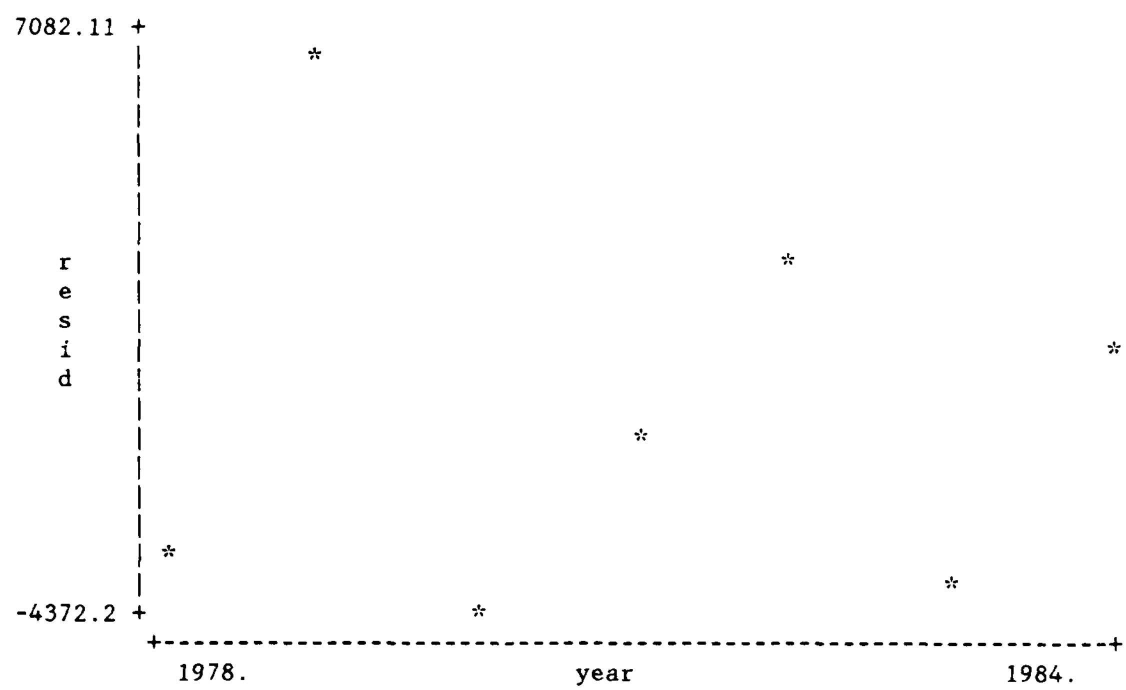

Table D.38

REGRESSION OF F-15 FSC11 ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	3.3328E+11	2	1.6664E+11
Residual	3.6184E+10	5	7.2369E+09
Total	3.6946E+11	7	5.2780E+10

Number of obs	=	7
F(2, 5)	=	23.03
Prob > F	=	0.0030
R-square	=	0.9021
Adj R-square	=	0.8629
Root MSE	=	85070.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc11					215541.
age	420559.2	195815.	2.148	0.084	.2717677
fh12	.3410131	.187838	1.815	0.129	300033.

Plot of Residuals fsc11

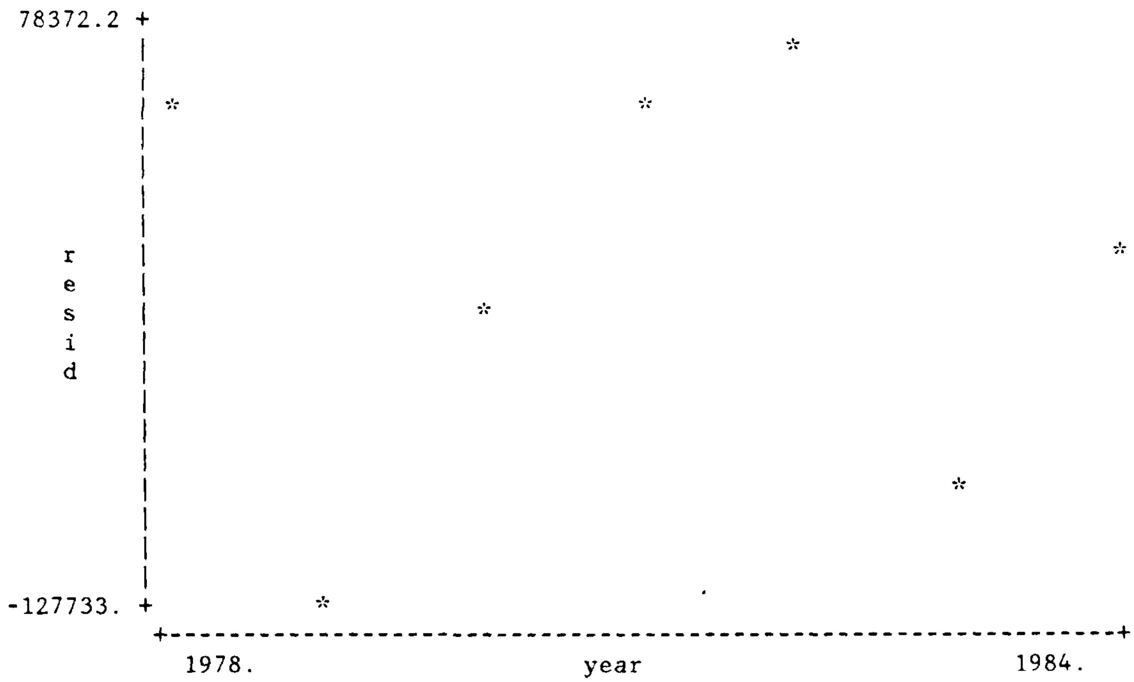

Table D.39

REGRESSION OF F-15 FSC13 ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	280220780.	2	140110390.
Residual	16351665.8	5	3270333.16
Total	296572446.	7	42367492.3

Number of obs =	7
F(2, 5) =	42.84
Prob > F =	0.0007
R-square =	0.9449
Adj R-square =	0.9228
Root MSE =	1808.4

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc13					6100.
age	17788.15	4162.613	4.273	0.008	.2717677
fh12	.0041675	.003993	1.044	0.344	300033.

Plot of Residuals fsc13

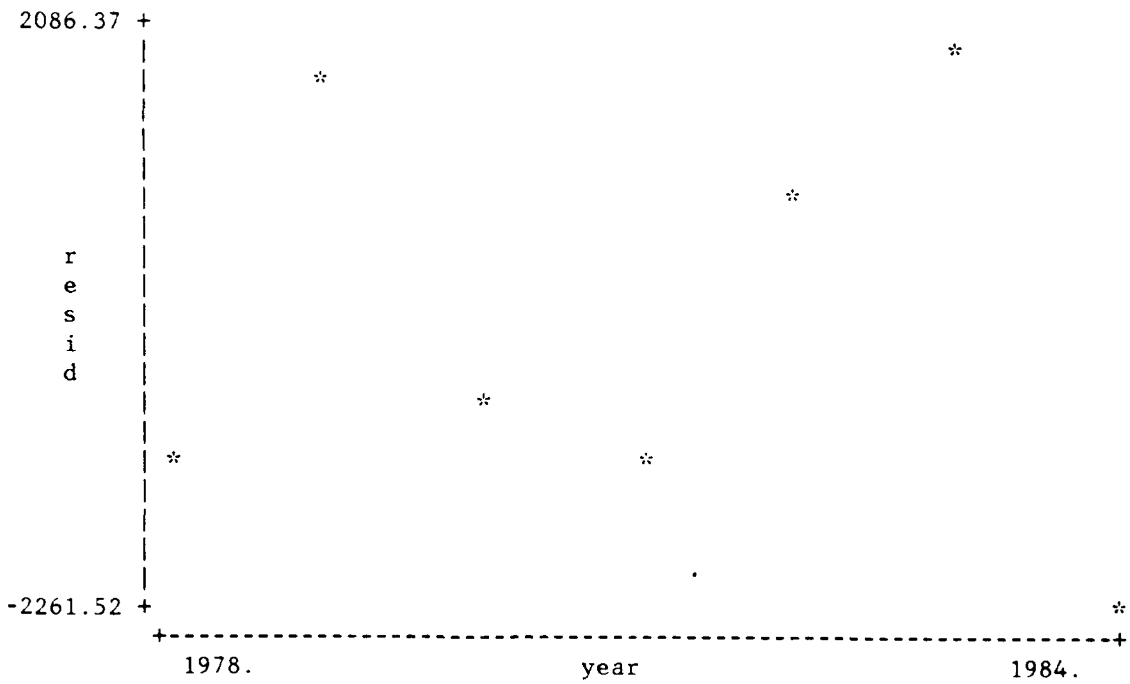

Table D.40

REGRESSION OF F-15 FSC14 ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	2.6516E+09	2	1.3258E+09
Residual	878321672.	5	175664334.
Total	3.5299E+09	7	504271201.

Number of obs =	7
F(2, 5) =	7.55
Prob > F =	0.0309
R-square =	0.7512
Adj R-square =	0.6516
Root MSE =	13254.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc14					17233.
age	-32668.59	30507.87	-1.071	0.333	.2717677
fh12	.087056	.029265	2.975	0.031	300033.

Plot of Residuals fsc14

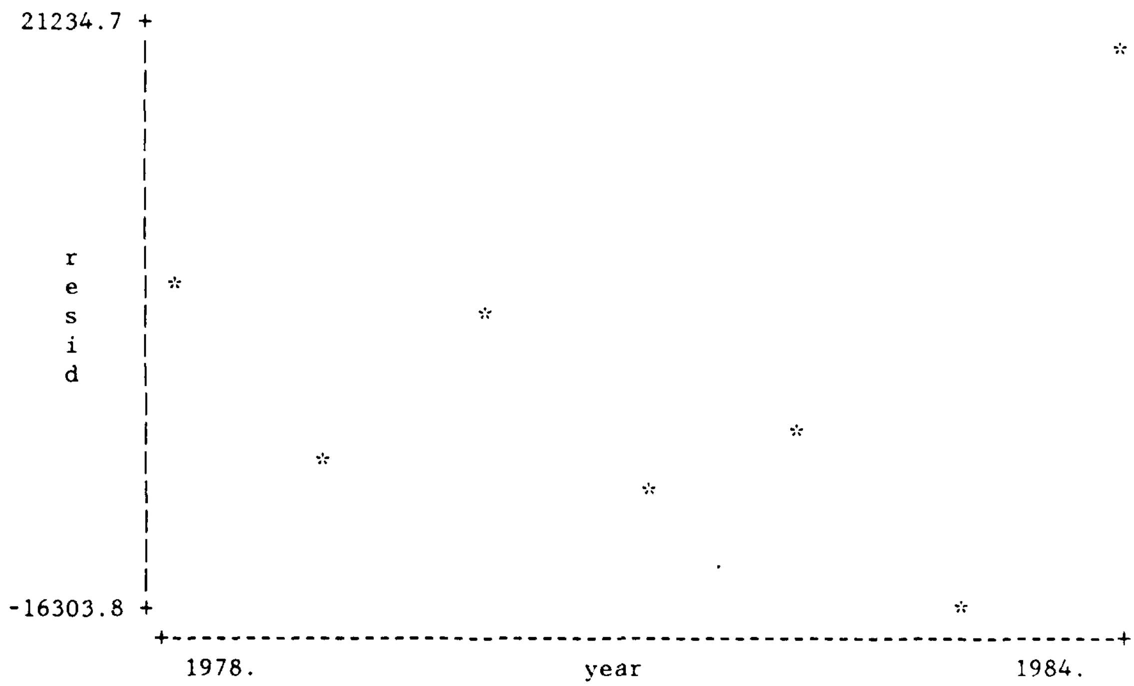

Table D.41

REGRESSION OF F-15 FSCSUM ON AGE AND FH12 WITH FSC1 AND FSC12 REMOVED

Source	SS	df	MS
Model	1.0580E+12	2	5.2898E+11
Residual	9.1720E+10	5	1.8344E+10
Total	1.1497E+12	7	1.6424E+11

Number of obs	=	7
F(2, 5)	=	28.84
Prob > F	=	0.0018
R-square	=	0.9202
Adj R-square	=	0.8883
Root MSE	=	1.4E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					385655.7
age	701021.	311758.1	2.249	0.074	.2717677
fh12	.6543221	.2990578	2.188	0.080	300033.

Plot of Residuals, fscsum with fsc1 and fsc12 deleted

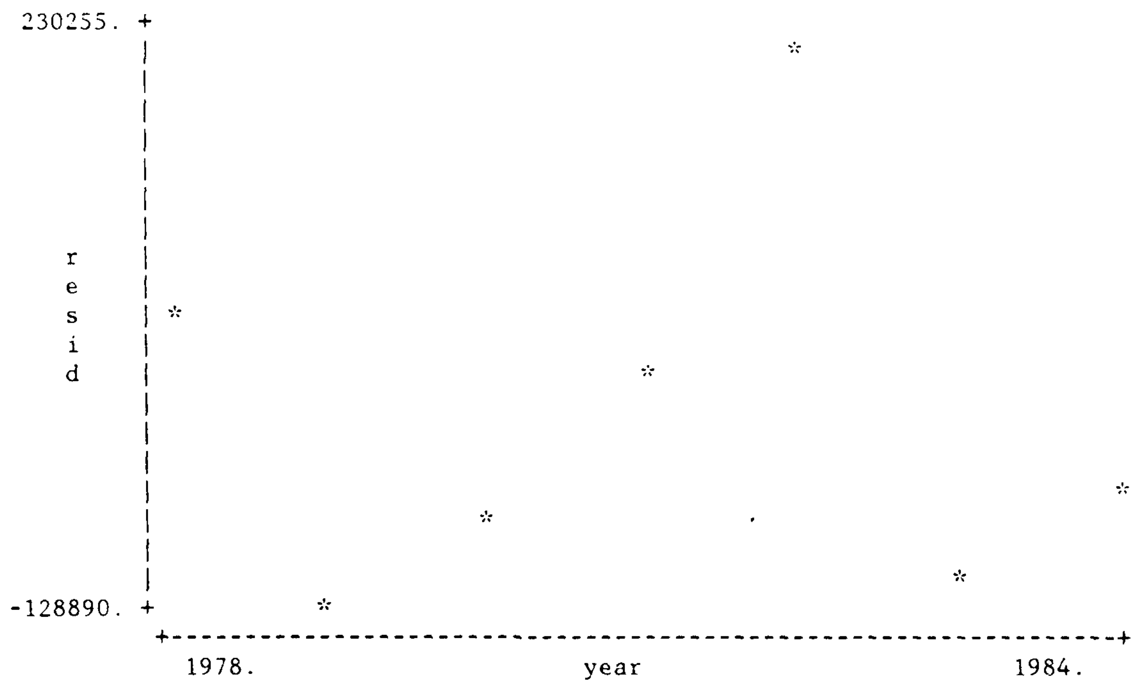

Table D.42

REGRESSION OF F-15 FSCSUM ON AGE AND FH12 WITH FSC1, FSC12, AND FSC3 REMOVED

Source	SS	df	MS
Model	8.0803E+11	2	4.0401E+11
Residual	6.0574E+10	5	1.2115E+10
Total	8.6860E+11	7	1.2409E+11

Number of obs	=	7
F(2, 5)	=	33.35
Prob > F	=	0.0013
R-square	=	0.9303
Adj R-square	=	0.9024
Root MSE	=	1.1E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					336026.7
age	657710.2	253353.8	2.596	0.048	.2717677
fh12	.5281855	.2430328	2.173	0.082	300033.

Plot of Residuals, fscsum with fsc1, fsc12, and fsc3 deleted

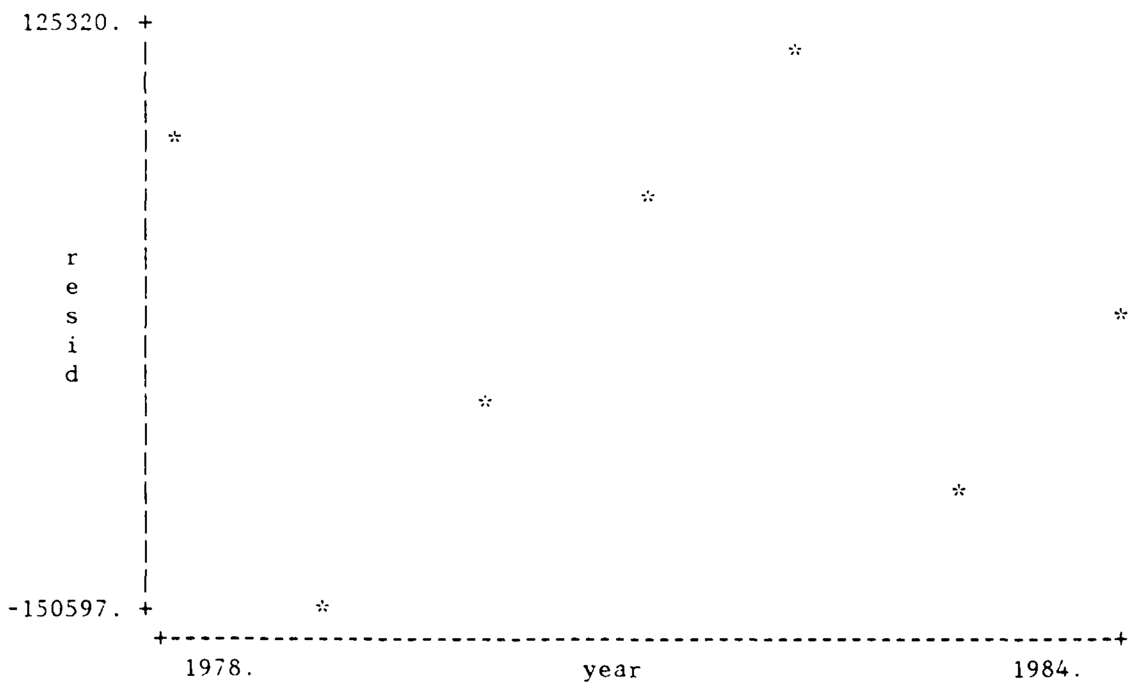

Table D.43

REGRESSION OF F-16 FSCSUM ON AGE AND FH12

Source	SS	df	MS
Model	1.3162E+12	2	6.5812E+11
Residual	2.5870E+11	4	6.4676E+10
Total	1.5749E+12	6	2.6249E+11

Number of obs	=	6
F(2, 4)	=	10.18
Prob > F	=	0.0270
R-square	=	0.8357
Adj R-square	=	0.7536
Root MSE	=	2.5E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					449357.
age	964287.9	331501.	2.909	0.044	.4035577
fh12	.2416479	.4538754	0.532	0.623	277972.

Plot of Residuals fscsum

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 380820. +
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         |
         |                                  *
         |
-263920. + *
          +-------------------------------------------------------------+
           1979.                      year                       1984.
```

Table D.44

REGRESSION OF F-16 FSC1 ON AGE AND FH12

Source	SS	df	MS
Model	18558596.0	2	9279298.01
Residual	36194199.0	4	9048549.75
Total	54752795.0	6	9125465.83

Number of obs =	6
F(2, 4) =	1.03
Prob > F =	0.4370
R-square =	0.3390
Adj R-square =	0.0084
Root MSE =	3008.1

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc1					1570.5
age	78.16384	3921.048	0.020	0.985	.4035577
fh12	.0055428	.0053685	1.032	0.360	277972.

Plot of Residuals fscl

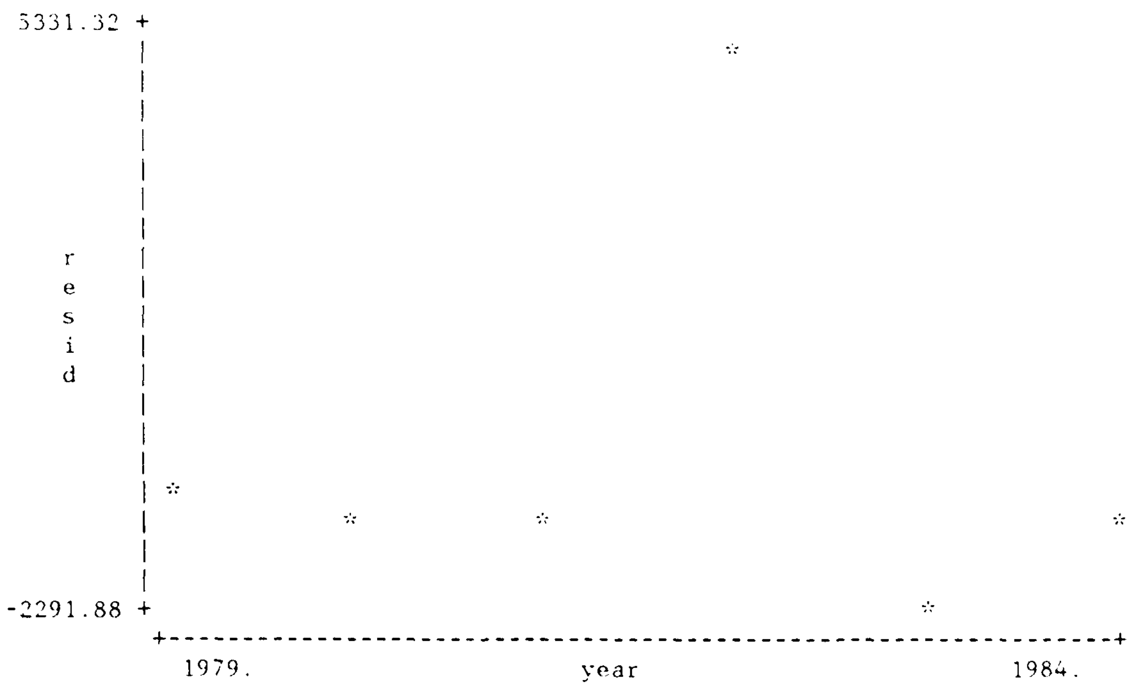


Table D.45

REGRESSION OF F-16 FSC2 ON AGE AND FH12

Source	SS	df	MS
Model	9.7681E+10	2	4.8841E+10
Residual	1.8938E+10	4	4.7346E+09
Total	1.1662E+11	6	1.9437E+10

Number of obs =	6
F(2, 4) =	10.32
Prob > F =	0.0264
R-square =	0.8376
Adj R-square =	0.7564
Root MSE =	68808.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc2					116496.2
age	309536.1	89692.21	3.451	0.026	.4035577
fh12	-.0244936	.1228023	-0.199	0.852	277972.

Plot of Residuals fsc2

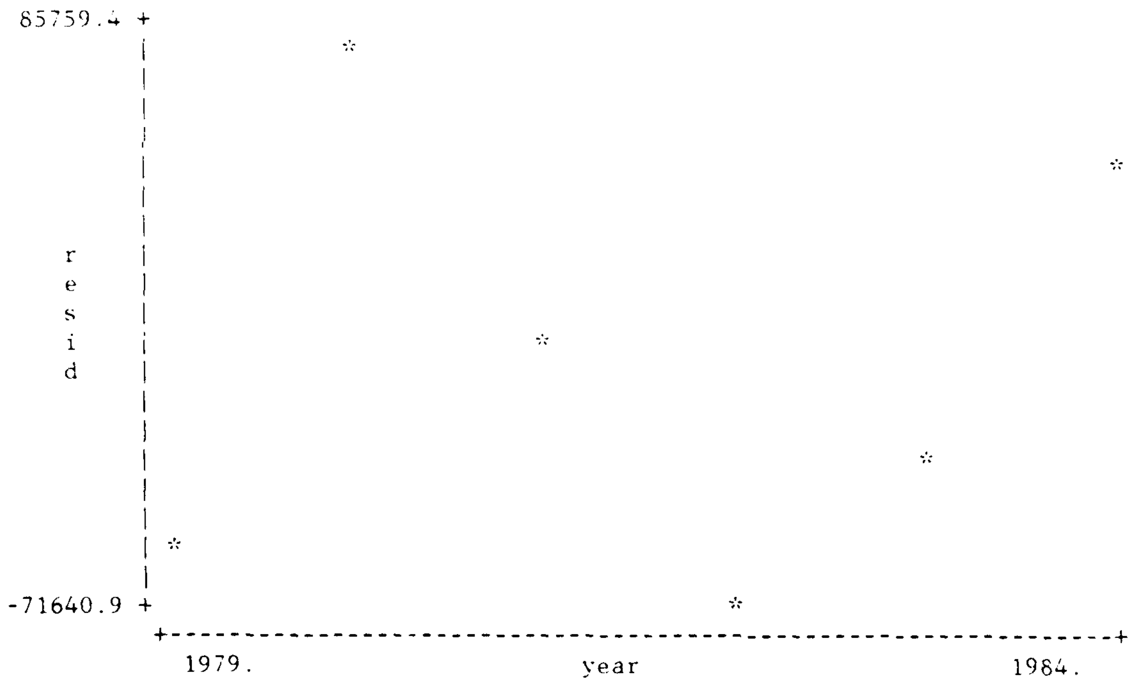


Table D.46

REGRESSION OF F-16 FSC3 ON AGE AND FH12

Source	SS	df	MS
Model	1.7434E+11	2	8.7171E+10
Residual	7.5014E+10	4	1.8753E+10
Total	2.4936E+11	6	4.1559E+10

Number of obs	=	6
F(2, 4)	=	4.65
Prob > F	=	0.0905
R-square	=	0.6992
Adj R-square	=	0.5488
Root MSE	=	1.4E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc3					163373.8
age	346677.	178506.4	1.942	0.124	.4035577
fh12	.0955031	.2444025	0.391	0.716	277972.

Plot of Residuals fsc3

```
 196698. +
         |             *
         |
         |
         |
         |
         |
         |
    r    |
    e    |
    s    |                                                     *
    i    |                           *
    d    |
         |                                        *
         |                                                                  *
         |
         |
         |
         |
         |
-179076. + *
          +----------------------------------------------------------------+
           1979.                       year                          1984.
```

Table D.47

REGRESSION OF F-16 FSC4 ON AGE AND FH12

Source	SS	df	MS
Model	488069945.	2	244034972.
Residual	107380738.	4	26845184.5
Total	595450683.	6	99241780.5

Number of obs	=	6
F(2, 4)	=	9.09
Prob > F	=	0.0325
R-square	=	0.8197
Adj R-square	=	0.7295
Root MSE	=	5181.2

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc4					8879.833
age	15076.68	6753.765	2.232	0.089	.4035577
fh12	.0104429	.0092469	1.129	0.322	277972.

Plot of Residuals fsc4

```
 6353.1 +
        |                                        *
        |
        |
        |
        |              *
        |
        |
      r |
      e |
      s |
      i |                                                     *
      d |
        |
        | *                                                                *
        |
        |
        |
        |
        |
-6523.32 +                           *
         +-------------------------------------------------------------------+
          1979.                     year                           1984.
```

Table D.48

REGRESSION OF C-5 FSC5 ON AGE AND FH12

Source	SS	df	MS
Model	298715168.	2	149357584.
Residual	233391988.	4	58347997.0
Total	532107156.	6	88684526.0

Number of obs	=	6
F(2, 4)	=	2.56
Prob > F	=	0.1924
R-square	=	0.5614
Adj R-square	=	0.3421
Root MSE	=	7638.6

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc5					6437.333
age	16351.09	9956.935	1.642	0.176	.4035577
fh12	.0002126	.0136326	0.016	0.988	277972.

Plot of Residuals fsc5

```
11800.5 +
        |          *
        |
        |
        |
        |
        |
        |
  r     |
  e     |
  s     |                                                       *
  i     |                                              *
  d     |
        |
        |
        |
        |                     *             *
        |
        |
-7591.96 + *
         +-------------------------------------------------------+
          1979.                 year                        1984.
```

Table D.49

REGRESSION OF F-16 FSC6 ON AGE AND FH12

Source	SS	df	MS
Model	2.0306E+09	2	1.0153E+09
Residual	1.0169E+09	4	254215354.
Total	3.0475E+09	6	507916105.

Number of obs	=	6
F(2, 4)	=	3.99
Prob > F	=	0.1113
R-square	=	0.6663
Adj R-square	=	0.4995
Root MSE	=	15944.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc6					16871.33
age	42642.67	20783.26	2.052	0.109	.4035577
fh12	.0005328	.0284554	0.019	0.986	277972.

Plot of Residuals fsc6

```
  24496. +
         |             *
         |
         |
         |
         |
         |
         |
   r     |
   e     |
   s     |                                                                 *
   i     |
   d     |
         |
         |
         |                                       *            *
         |                          *
         |
         |
         |
-16843.1 + *
          +-----------------------------------------------------------------+
            1979.                      year                            1984.
```

Table D.50

REGRESSION OF F-16 FSC7 ON AGE AND FH12

Source	SS	df	MS
Model	661587840.	2	330793920.
Residual	207610094.	4	51902523.4
Total	869197934.	6	144866322.

Number of obs	=	6
F(2, 4)	=	6.37
Prob > F	=	0.0571
R-square	=	0.7611
Adj R-square	=	0.6417
Root MSE	=	7204.3

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc7					10261.
age	19889.08	9390.894	2.118	0.102	.4035577
fh12	.0083999	.0128576	0.653	0.549	277972.

Plot of Residuals fsc7

```
6849.81 +
        |      *
        |
        |                           *
        |
        |                  *
        |
        |
   r    |
   e    |
   s    |
   i    |                                     *
   d    |
        |
        |                                               *
        |
        |
        |
        |
        |
-9953.4 + *
         +------------------------------------------------+
           1979.                 year                 1984.
```

Table D.51

REGRESSION OF F-16 FSC9 ON AGE AND FH12

Source	SS	df	MS
Model	100026375.	2	50013187.4
Residual	8933839.14	4	2233459.79
Total	108960214.	6	18160035.7

Number of obs	=	6
F(2, 4)	=	22.39
Prob > F	=	0.0067
R-square	=	0.9180
Adj R-square	=	0.8770
Root MSE	=	1494.5

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc9					3969.333
age	3290.68	1948.058	1.689	0.166	.4035577
fh12	.00954	.0026672	3.577	0.023	277972.

Plot of Residuals fsc9

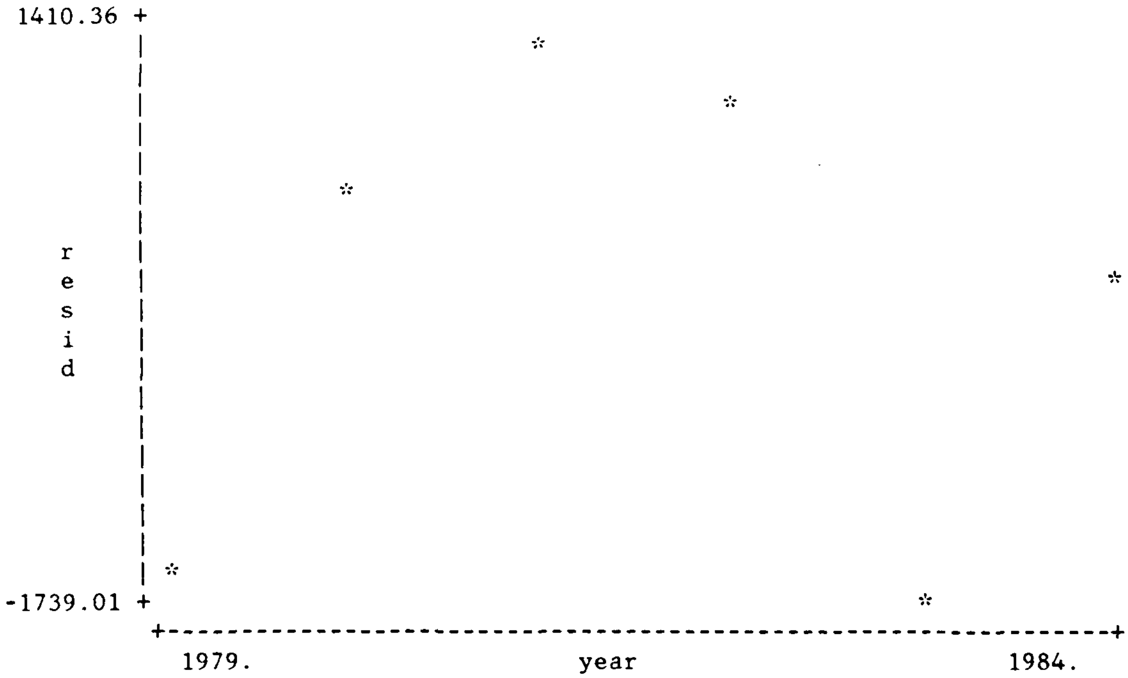


Table D.52

REGRESSION OF F-16 FSC10 ON AGE AND FH12

Source	SS	df	MS
Model	2.8975E+10	2	1.4487E+10
Residual	2.5907E+09	4	647680710.
Total	3.1566E+10	6	5.2609E+09

Number of obs	=	6
F(2, 4)	=	22.37
Prob > F	=	0.0067
R-square	=	0.9179
Adj R-square	=	0.8769
Root MSE	=	25450.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc10					54945.
age	199773.8	33173.65	6.022	0.004	.4035577
fh12	-.0902197	.0454198	-1.986	0.118	277972.

Plot of Residuals fsc10

```
  32171. +
         |             *
         |
         |
         |
         |
         |
         |                                                     *
    r    |
    e    |                                                                  *
    s    |
    i    |
    d    |
         |
         |
         | *
         |
         |                           *
         |
         |
-28462.9 +                                        *
          +-----------------------------------------------------------------+
            1979.                      year                          1984.
```

Table D.53

REGRESSION OF F-16 FSC11 ON AGE AND FH12

Source	SS	df	MS
Model	9.5677E+09	2	4.7838E+09
Residual	2.7906E+09	4	697659828.
Total	1.2358E+10	6	2.0597E+09

Number of obs =	6
F(2, 4) =	6.86
Prob > F =	0.0510
R-square =	0.7742
Adj R-square =	0.6613
Root MSE =	26413.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc11					35701.17
age	5420.5	34429.81	0.157	0.883	.4035577
fh12	.1223404	.0471397	2.595	0.060	277972.

Plot of Residuals fsc11

```
 27516.7 +
         |                                                          *
         |
         |
         |          *
         |
         |
         |
     r   | *
     e   |
     s   |                                               *
     i   |
     d   |
         |
         |
         |
         |
         |                    *
         |
-32586.9 +                              *
          +-----------------------------------------------------------+
          1979.                  year                          1984.
```

Table D.54

REGRESSION OF F-16 FSC13 ON AGE AND FH12

Source	SS	df	MS
Model	973524937.	2	486762469.
Residual	214282701.	4	53570675.1
Total	1.1878E+09	6	197967940.

Number of obs	=	6
F(2, 4)	=	9.09
Prob > F	=	0.0325
R-square	=	0.8196
Adj R-square	=	0.7294
Root MSE	=	7319.2

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc13					11261.67
age	34103.27	9540.613	3.575	0.023	.4035577
fh12	-.0097219	.0130626	-0.744	0.498	277972.

Plot of Residuals fsc13

```
8922.01 +
        |                         *
        |
        |
        |
        |
        |
        | *
        |
      r |
      e |
      s |                                      *                         *
      i |
      d |
        |
        |                                                   *
        |
        |
        |
        |
        |
-9898.18 +           *
         +------------------------------------------------------------+
          1979.                   year                          1984.
```

Table D.55

REGRESSION OF F-16 FSC14 ON AGE AND FH12

Source	SS	df	MS
Model	4.9199E+09	2	2.4599E+09
Residual	4.2868E+09	4	1.0717E+09
Total	9.2067E+09	6	1.5344E+09

Number of obs =	6
F(2, 4) =	2.30
Prob > F =	0.2168
R-square =	0.5344
Adj R-square =	0.3016
Root MSE =	32737.

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc14					19589.83
age	-28551.13	42672.52	-0.669	0.540	.4035577
fh12	.1135686	.0584252	1.944	0.124	277972.

Plot of Residuals fsc14

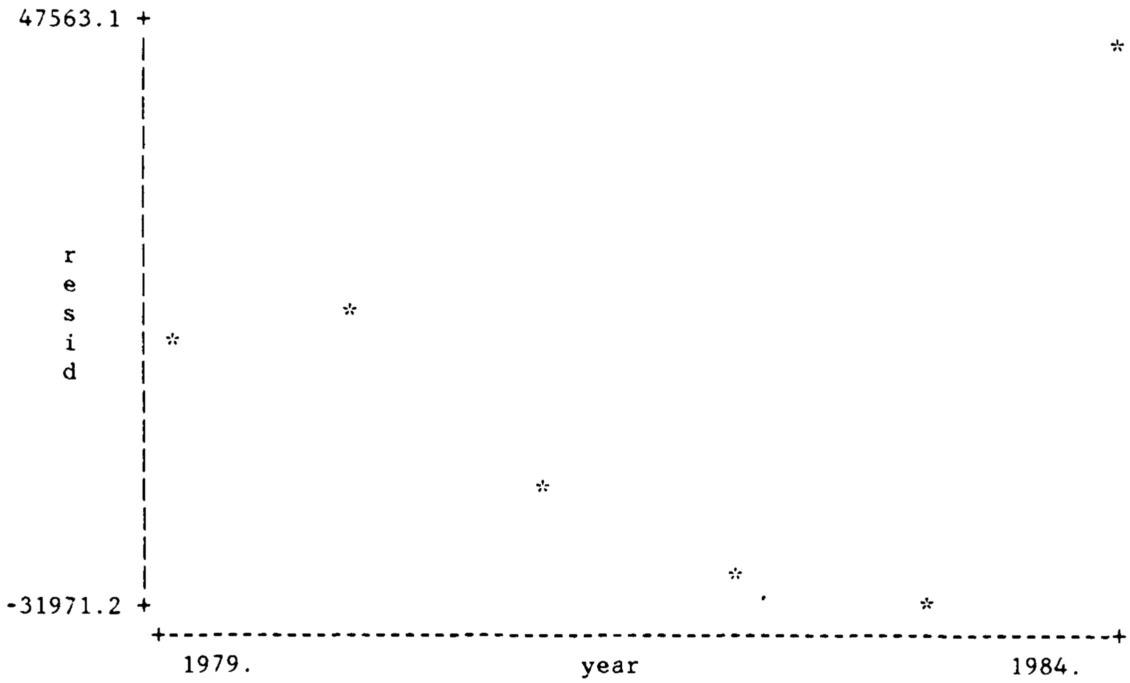


Table D.56

REGRESSION OF F-16 FSCSUM ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	1.2598E+12	2	6.2991E+11
Residual	2.3495E+11	4	5.8738E+10
Total	1.4948E+12	6	2.4913E+11

Number of obs	=	6
F(2, 4)	=	10.72
Prob > F	=	0.0247
R-square	=	0.8428
Adj R-square	=	0.7642
Root MSE	=	2.4E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					434260.4
age	999030.8	315915.9	3.162	0.034	.4035577
fh12	.1349751	.432537	0.312	0.771	277972.

Plot of Residuals fscsum

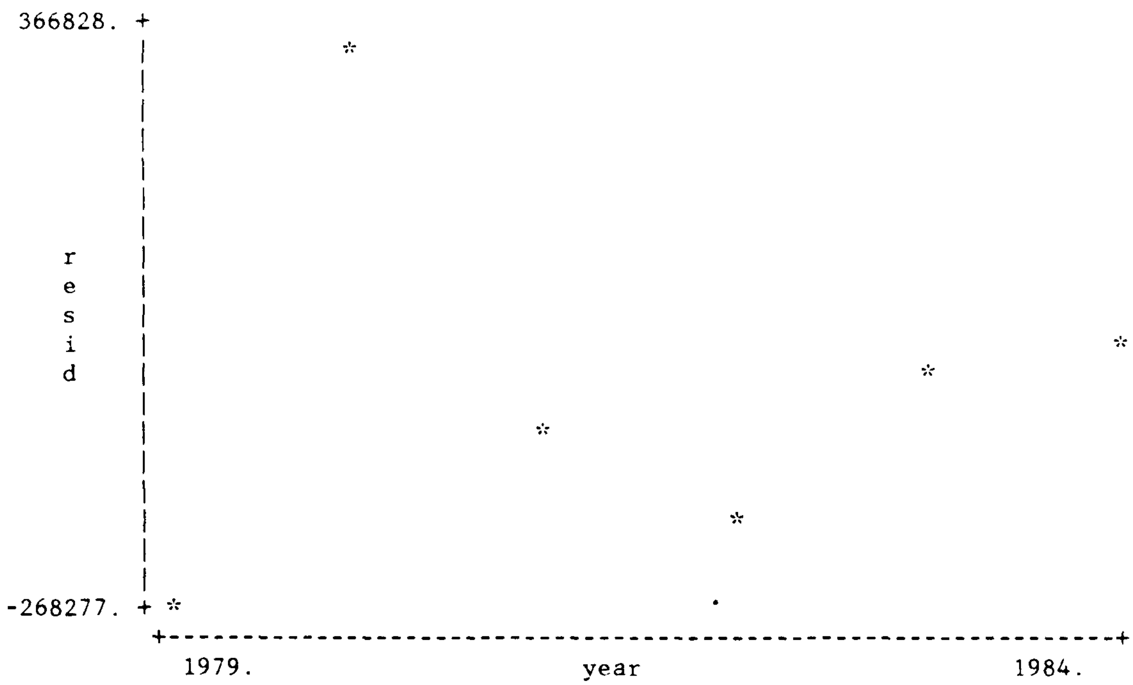


Table D.57

REGRESSION OF F-16 FSC7 ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS		
Model	652200915.	2	326100457.	Number of obs =	6
Residual	65338491.0	4	16334622.8	F(2, 4) =	19.96
Total	717539406.	6	119589901.	Prob > F =	0.0083
				R-square =	0.9089
				Adj R-square =	0.8634
				Root MSE =	4041.6

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc7					10261.
age	20898.32	5268.261	3.967	0.017	.4035577
fh12	.0063765	.0072131	0.884	0.427	277972.

Plot of Residuals fsc7

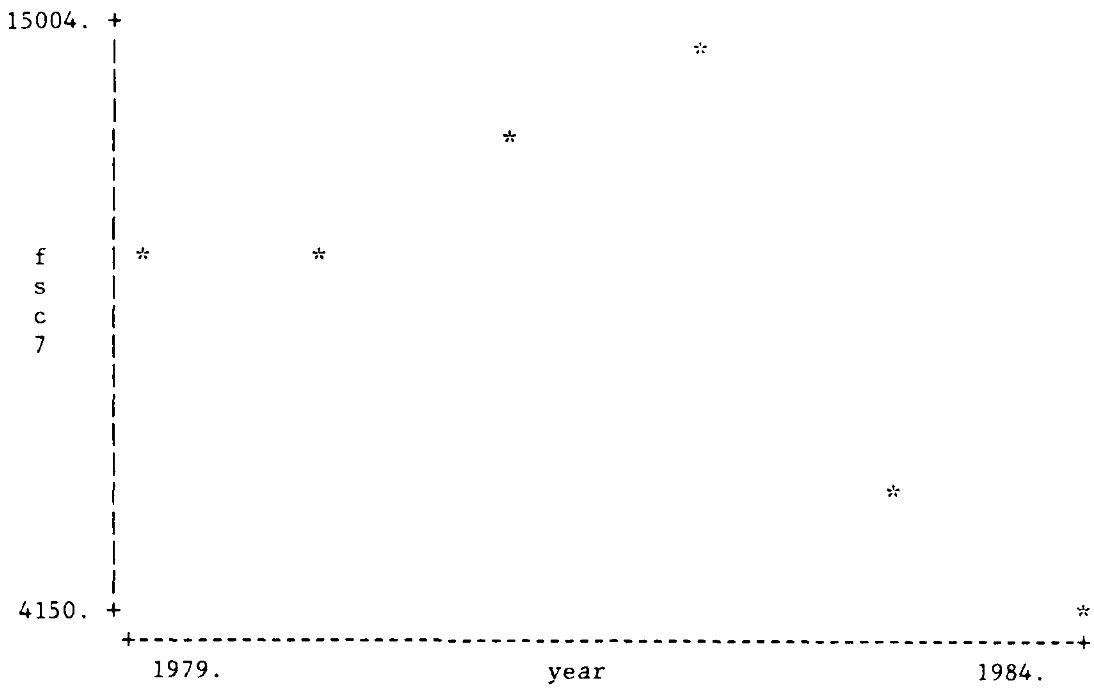


Table D.58

REGRESSION OF FSC14 ON AGE AND FH12 WITH OUTLIERS REMOVED

Source	SS	df	MS
Model	127281349.	2	63640674.4
Residual	60699353.1	4	15174838.3
Total	187980702.	6	31330117.0

Number of obs	=	6
F(2, 4)	=	4.19
Prob > F	=	0.1043
R-square	=	0.6771
Adj R-square	=	0.5156
Root MSE	=	3895.5

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fsc14					4493.2
age	5182.566	5077.79	1.021	0.365	.4035577
fh12	.0089192	.0069523	1.283	0.269	277972.

Plot of Residuals fsc14

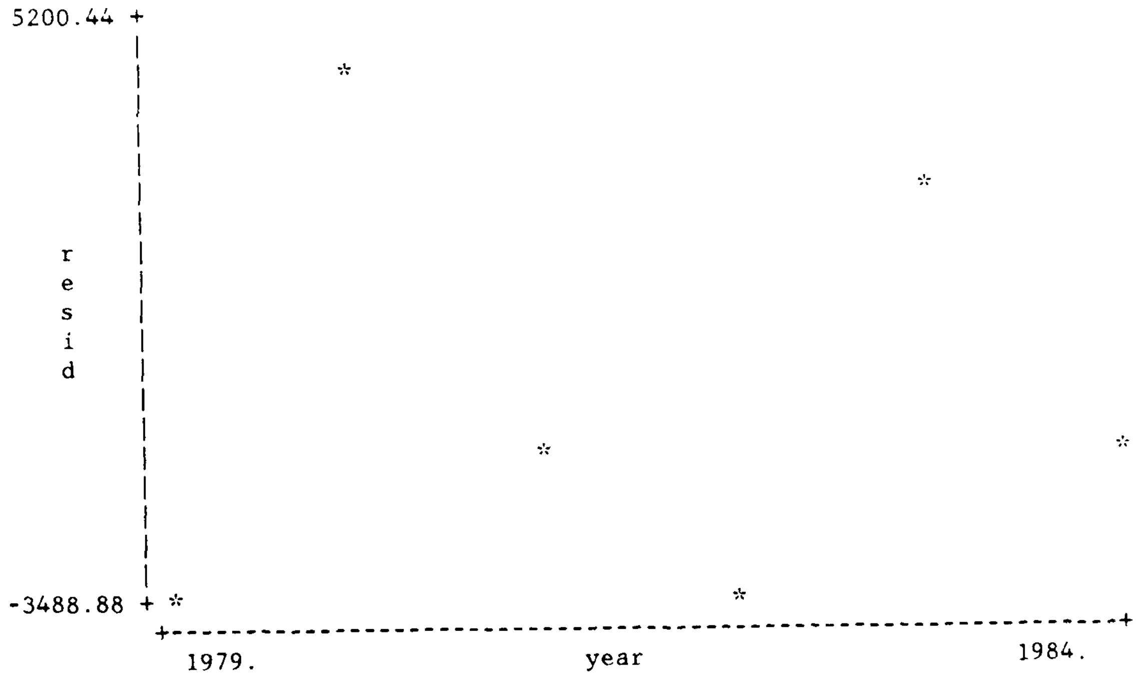


Table D.59

REGRESSION OF F-16 FSCSUM WITH FSC1 AND FSC5 REMOVED

Source	SS	df	MS
Model	1.2257E+12	2	6.1286E+11
Residual	2.2854E+11	4	5.7135E+10
Total	1.4543E+12	6	2.4238E+11

Number of obs	=	6
F(2, 4)	=	10.73
Prob > F	=	0.0247
R-square	=	0.8428
Adj R-square	=	0.7643
Root MSE	=	2.4E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					427838.3
age	990060.4	311575.5	3.178	0.034	.4035577
fh12	.1244443	.4265943	0.292	0.785	277972.

Plot of Residuals fscsum

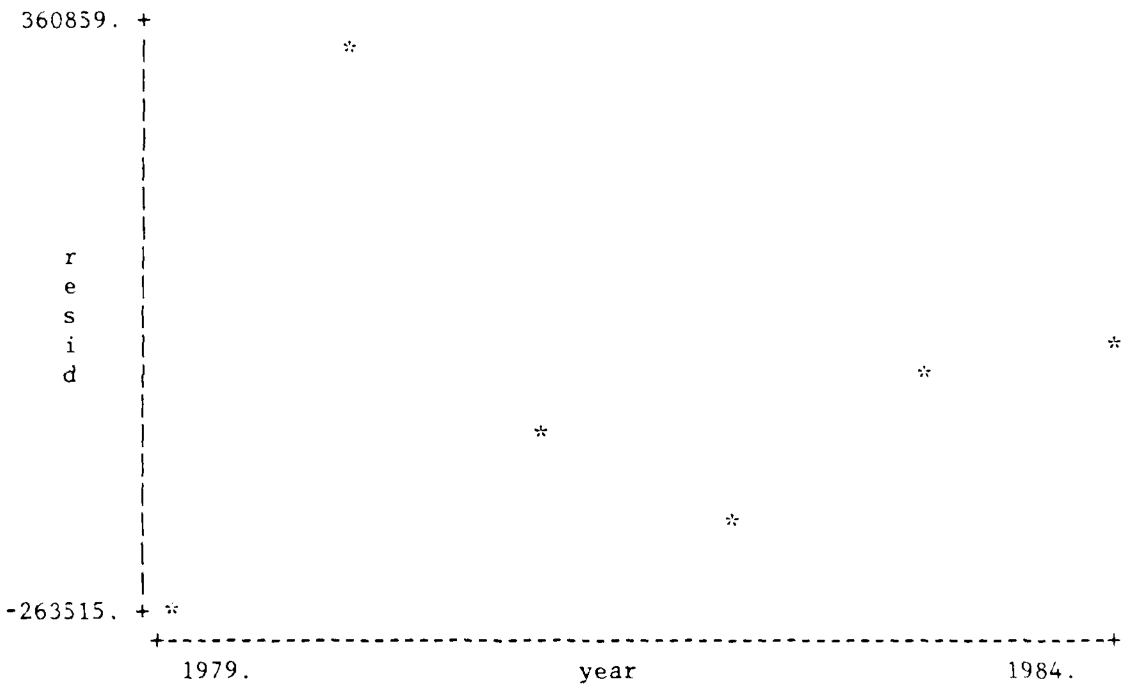


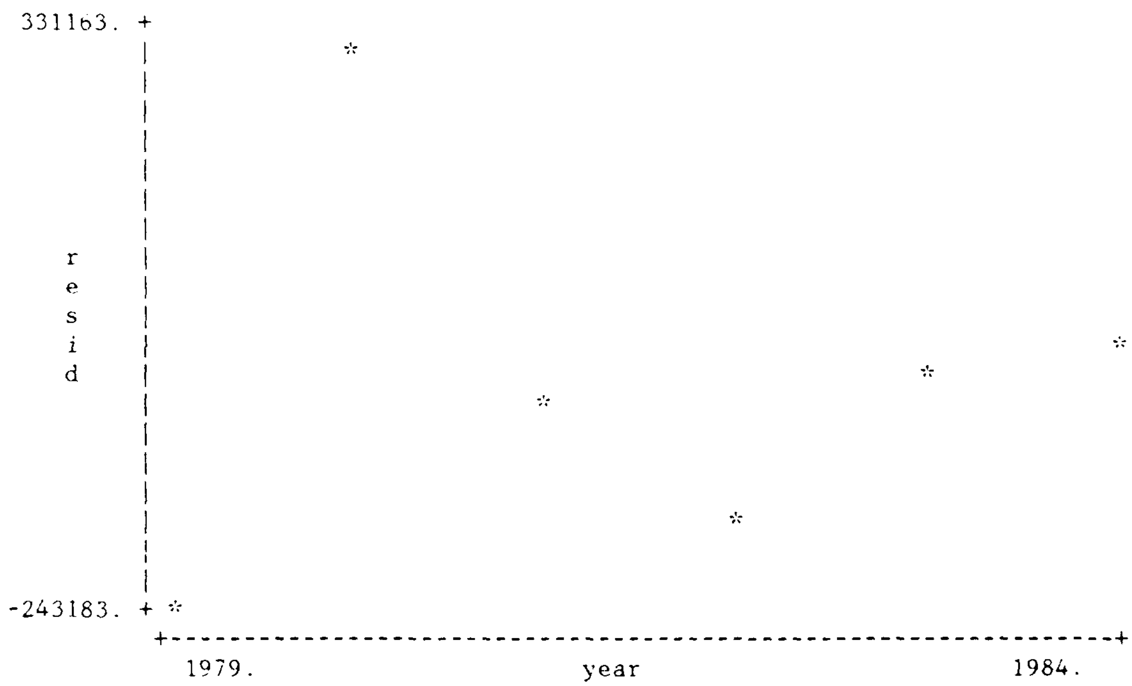
Table D.60

REGRESSION OF F-16 FSCSUM
WITH FSC1, FSC5, FSC6, AND FSC14 REMOVED

Source	SS	df	MS		
				Number of obs =	6
				F(2, 4) =	11.40
Model	1.1061E+12	2	5.5306E+11	Prob > F =	0.0223
Residual	1.9405E+11	4	4.8513E+10	R-square =	0.8508
				Adj R-square =	0.7761
Total	1.3002E+12	6	2.1670E+11	Root MSE =	2.2E+05

Variable	Coefficient	Std. Error	t	Prob > |t|	Mean
fscsum					406473.8
age	942235.1	287104.9	3.282	0.030	.4035577
fh12	.1149923	.3930904	0.293	0.784	277972.

Plot of Residuals fscsum



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